A MODEL DOCUMENT PRODUCTION SYSTEM

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INTRODUCTION

This report presents the conceptual design of a system to support effectively the entire technical document production process. It includes a wide range of computer-based aids that will interest technical document production specialists, system builders, and anyone concerned with the future of document production. However, it is not simply a collection of isolated tools. It is a complete, integrated system that provides access to any one or all of the computer aids for unsophisticated and experienced users as well as a framework for monitoring the entire production process. The term "technical document" is used in this report to mean technical information that can be made available in printed form. This definition is very broad and encompasses documents ranging in size from short, informal letters through articles in technical journals to books, reports, manuals, or parts lists. Within this definition, a document may contain any combination of text, tables, drawings, and photographs.

In the Document Production and Control Systems Design Study Phase One Report, we examined in detail three large technical document production processes to identify the functions involved. Commercially available aids to these functions were described and their features and effectiveness were analyzed. The analysis in the first report of the needs and tools for producing technical documents is the basis of the generalizations made in this Phase Two report. We specify here the basic functions in the production process and describe an ideal computer-based document production system, including an optimum set of computer aids for each function. This optimum set of computer aids is discussed without considering existing systems, including the Augmentation Research Center's NLS (the oNLine System). A subsequent Phase Three report will compare this model system with NLS, examining NLS to determine which requirements of the model system it meets and which it does not meet.

The model system presented in this report integrates all the computer aids that we understand to be both useful and possible.

The system is not fantastic in terms of technical development. With the exception of the large displays described in the section on the Work Station, every feature described in this report is currently operating at least as an isolated prototype, mostly as parts of scattered commercial systems. No capability is included if we cannot foresee its development in the near future. For this reason we use the simple future tense in this report, i.e., "This system will...." Although it is highly probable that many of these features will be available for general use in the near future, whether they will all be included in a single integrated system depends on the foresight, planning, and determination of the people who do the development and implementation work and the people who support it.

Document production resembles many industrial processes, for example, the manufacture of chemicals, in which the same factory is used to make many closely related products. Similarly, workers make every document with the same tools. The documents on a production line are uniform in many ways, however, they have important differences. To be efficient, document production tools must take advantage of the similarity of the documents, but they must be flexible enough to accommodate the differences, which frequently require a variety of loops backward in the production process.

In many industries, the flow of products through the production process is now controlled by computer. In industrial control processes, analog and digital sensors and human input provide the computer with the data necessary to determine the current state of the product. Similarly, the state of a document can be monitored--the size of sections; the author's and editor's names associated with particular material, including the dates and times when changes were made--and the state of the review and layout processes may be controlled automatically. The model system described in this report attempts to capitalize on this feature by outlining methods of control much superior to those now in use, in terms of both rapid error-free transfer from step to step and accurate instant information on the state of production. We develop this subject further in the section below on the Agent.

Document production is also a circular process that may begin with an idea or a need for information and progress through information gathering and writing, review and approval, reproduction, and distribution. The cycle is completed with the use of the document by succeeding writers. This study differs from many previous efforts by considering the whole circular process, illustrated schematically in Figure 1. The flow chart uses the following conventions: boxes describe the state of the document and diamonds describe decision or repetition points; the links between the boxes and diamonds represent the actions or functions necessary to move the document from one state to the next. The control and communication functions, described below, are not represented in the diagram because they occur during every stage of the production process.

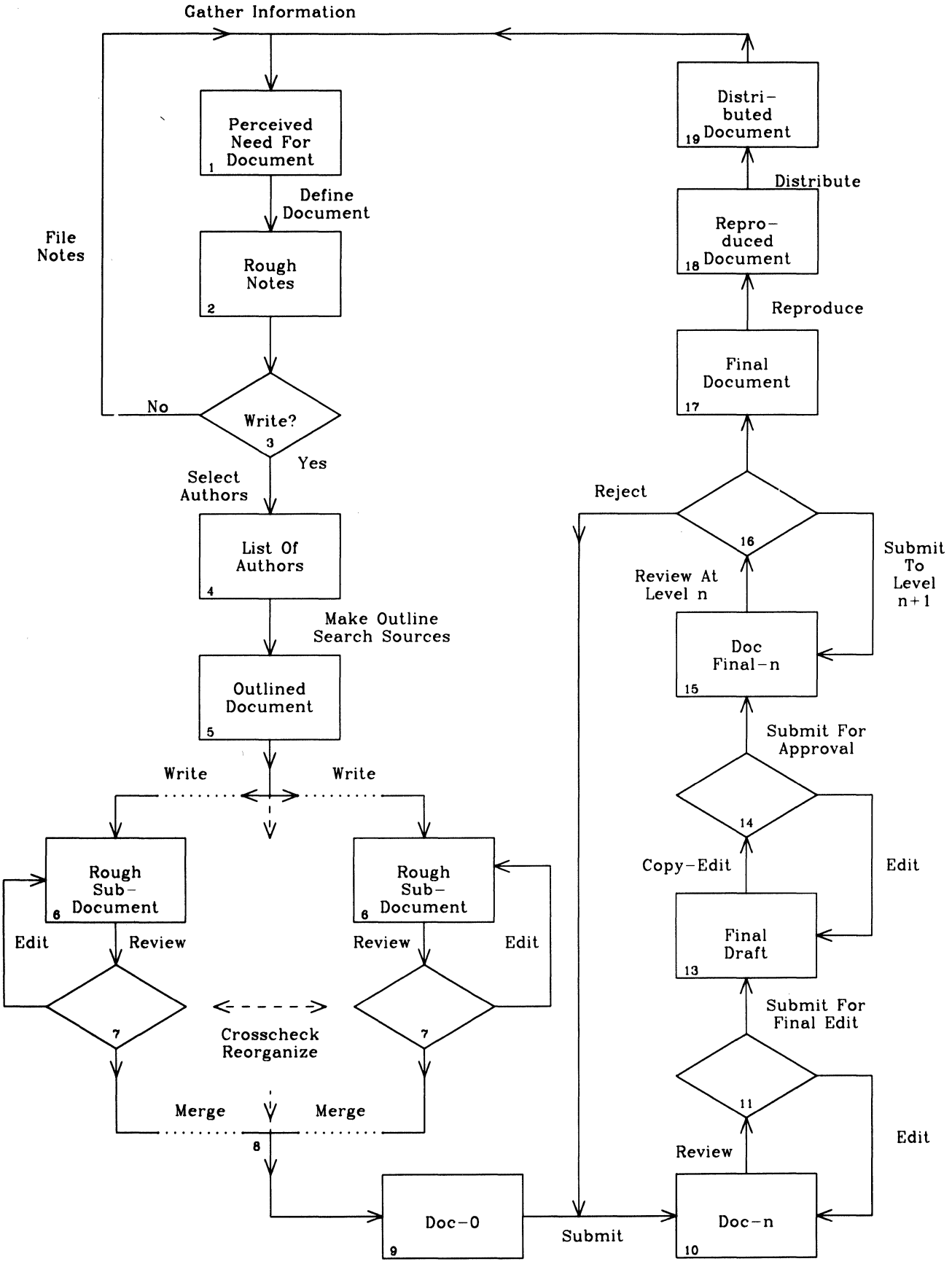
Gather Information
Perceived Need For Document
1
Define Document
Rough Notes
2
File Notes
No
Write?
3
Yes
Select Authors
List Of Authors
4
Make Outline Search Sources
Outlined Document
5
Write
Write
Rough Sub-Document
6
Rough Sub-Document
6
Edit
Review
Review
Edit
7
7
Crosscheck Reorganize
Merge
Merge
8
Doc-0
9
Submit
Doc-n
10
Review
Edit
11
Submit For Final Edit
Final Draft
13
Copy-Edit
Edit
14
Submit For Approval
Doc Final-n
15
Review At Level n
Reject
Submit To Level n+1
16
Final Document
17
Reproduce
Reproduced Document
18
Distribute
Distributed Document
19

Figure 1

PRODUCTION FUNCTIONS

This section characterizes the basic functions in technical document production: information gathering, writing, editing, reviewing, layout, reproduction, distribution, control, and communication. Each function is defined and keyed to its place on the flow chart, Figure 1. Insofar as production functions depend on media, we discuss them in terms of computer services or their manual equivalents. For example, careful proofing for format is an important subfunction of editing in manual systems, but a properly designed computer-based system will require only cursory scanning of format. Computer aids are discussed here only in a general way; the value and problems of specific implementations are reserved for later sections.

In practice, many document production functions overlap. We have found it useful to name groups of closely associated tasks and characterize their boundaries (such as the boundary between editing and reviewing) rather than talking about the functions as if they were wholly isolated.

Information Gathering

Information gathering includes the entire process by which writers acquire the information they use to write a document. Information gathering begins before writing starts, and, though it diminishes after the writing stage, it ends only when the document is published. The product of information gathering is all the contents of the document that are not newly conceived during writing and editing. In the flow chart, the process begins at some indefinite time before step 1 and extends through step 16.

In present manual systems, information gathering involves searching and finding information and recording it in a form ready for use in writing. Searching includes a wide range of activities, such as talking with people, correspondence, using reference services, reading other documents, scanning computer code, watching movies and television, and even observing events. Recording for use in writing usually means either committing something to memory or making

a paper copy of some kind, for example, making xerographic copies of articles, obtaining carbons of forms, obtaining printouts from computer systems, taking notes, and so on.

Present computer systems include a large and growing volume of technical information that is available online. The majority of these information services provide references or abstracts, usually printed out rather than in a form that other computer systems can manipulate. Some systems include the ability to access the full text of a document for retrieval, not just a citation or abstract. The availability of these systems is likely to increase as costs of large computer processors and mass storage devices decline. Such services, though they are usually very difficult to use, reduce searching time and provide information that would otherwise be missed. However, unless they incorporate full text retrieval capabilities, they do not aid the writing or publication process directly.

Writing

Writing is the process of communicating ideas in a readable narrative form. Besides directly creating narrative prose, writing includes copying parts of other documents, gradually filling out notes and outlines, creating graphics and tables, informally discussing content with colleagues, and reorganizing previously collected material. The process begins with the author's first effort to turn ideas and sources into document form and ends when a draft is released for editing or approval. In the flow chart, writing begins with step 5 and ends with step 6, although the response to review and editing, particularly before step 13, is often very much like writing.

In present manual systems, a writer uses a large variety of tools. Typically, an author begins with handwritten or typed notes. The author then pencils, types, or dictates a draft without regard to format. Notes may even be taped, glued, or stapled onto draft pages. The first draft may be reorganized by cutting and taping or by marking sections of text to be inserted as indicated when the draft is retyped. Sometimes a choice must be made between having a high-salaried author retype his rough material and having a lower-salaried typist struggle slowly through hard-to-read, handwritten drafts. This process may be repeated several times with or without typing help before the document leaves the writing stage.

Editing

Editing has a wide range of meaning from policy making (the editor of a large newspaper) to proofreading. Editing is used in this report to mean reviewing a draft of all or part of a document in order to suggest changes. An editor may suggest that the author reword or rewrite certain material to express ideas more clearly, and may make recommendations about the organization and content of the document, its conformity to the general standards of good language based on mechanical rules or on semantics, and its conformity to the standards of a particular publication. We consider the added work to implement the suggestions, including retyping, as part of the editing process.

Editing begins with a draft and ends with a new draft that is more nearly correct by some standard and that is clearer in expression. In the flow chart, editing by the author's co-workers takes place at steps 6 and 7, and editing by professional editors takes place at 10 and 11. Editing cycles may be repeated many times.

Different types of editing are performed on documents:

Wording. An editor thoughtfully reads the text in order to suggest rewording sentences and refining passages of text.

Organization. An editor reviews the overall structure of a document to ensure that it is organized consistently and logically.

Mechanical Errors. Mechanical errors are errors that can be evaluated by rules with-

out regard to context, for example, most spelling errors, spacing after punctuation marks, and the accuracy of lists of illustrations. However, the rules are not always consistent, and ingenuity is often necessary in handling difficult cases.

Grammatical Errors. Grammatical errors are errors in the use of language and punctuation that depend on context, for example, dangling participles, run-on sentences, or using "who" for "whom."

Tabular Material. Special attention has to be paid to correcting errors in tabular material, including checking arithmetic. Correcting tabular material manually often requires very time consuming retyping.

Format. In present manual systems, considerable editing or proofing of the format is necessary. Every page of a document must be checked for proper format, including margins, headers, footers, and so on. Editors of publications often require frequent retyping of pages to restore formats after changes in content.

Quality Control. Quality control involves checking the camera-ready copy for the visual quality of the typed pages (or microfilm) and for document features, such as running headers, related to format and critical for printing.

In present manual systems, editing typically begins with a publications specialist who reads a rough draft and pencils suggestions in the margins or list them on an attached piece of paper or a transparent overlay. The author annotates the editor's marks, and a typist makes a new draft from the accumulated commentary. This cycle is repeated with increasing emphasis on mechanical errors, such as typographical errors and punctuation. Cumulatively, it often means the equivalent of two or more retypings of the manuscript.

Reviewing

Reviewing is the process of reading a document and approving it, disapproving it, or making suggestions that the author must respond to before approval. The reviewer certifies that a document is suitable in content for its intended purpose. Like editing, reviewing may be repeated in complex cycles. Reviewers sometimes edit or evaluate previous editing, but reviewing differs from editing in its emphasis on content and on the reviewer's responsibility to assent to the document. Review begins with a document that may not proceed to the next step without approval, and ends when that document, possibly changed, has been approved to go on.

In the flow chart, review takes place between steps 10 and 15. The final review, steps 15 and 16, is distinct from the previous reviews because it is mostly performed at higher levels in the organizational hierarchy. Note that within this phase, the document may be rejected and returned to the author or to a lower level of review.

Reviewing includes a process of making suggestions that overlaps for wording and organization editing, and it also includes a sign-off procedure.

The process of handling suggestions resembles that of handling editorial suggestions on content. Suggestions and comments must be collected, considered, incorporated into the document if accepted, and retained for future reference.

Sign-off is one part of the control process described below. The control process must ensure that the document arrives for the reviewer's attention in proper form and in proper order. The reviewer must be able to communicate acceptance of the document and must have access to control information such as previous sign-offs, costs, and due dates.

Manual systems transport paper copies of documents to reviewers, often by inter-office mail and sometimes by U.S. mail. Clerical co-workers of the author or editor normally attach forms to documents that supply certain information about the history and makeup of the document and include a place to sign off. In offices dealing with a

large number of reviewers, further forms and filing are often necessary for the authors or editors to keep track of who is reviewing what and for how long, and to avoid any potential conflicts of interest.

Layout

Layout is the design of the printed page; it includes the entire process of producing camera-ready copy from a completed manuscript.

In present manual systems, layout ranges in complexity from handing a draft to a secretary who will type the reproduction-ready copy according to prescribed standards, to a careful method that begins when a typewritten manuscript is handed to a publications design specialist. The professional designer creates a "rough layout" for the document, drawing a blueprint for the actual printed page. Careful attention is given to all the design elements: typography, proportion, and space. The designer then creates a "comprehensive layout" to translate the rough layout into a reasonable facsimile of the printed page. Dummy type (typeset nonsense) or carefully drawn type indications are used to represent text areas; and headlines, titles, and headings are either set in type or carefully rendered. At this stage, the "comprehensive," the layout is appraised by the designer's client and/or supervisor. The comprehensive does not necessarily represent the final design; it may be modified or reorganized many times before it is approved (Hurlburt, 1976).

After the comprehensive has been approved, a typographer sets the manuscript in type as specified by the designer. A "rough proof," most often in the form of galleys, is made from the type and is delivered to the designer, who checks for type quality and typographical errors. When the type is approved, "reproduction proofs" (camera-ready quality) are delivered and the designer creates a "mechanical" for the printer, in which each page of the document is individually laid out according to the approved page format.

The basic production functions required for the layout process may include:

Design. The overall page layout and the style of the document are determined; practical and aesthetic decisions are made for each individual document. For technical publications, the design of a document is often determined by standard regulations. A visual representation of the initial design is produced that can be submitted to supervisors or clients for approval. Changes are very often requested, and the original design may be modified several times or even redesigned.

Copy Fitting. This is a straightforward arithmetical estimate of how much space a specified amount of text, will occupy when it is set in type. The designer uses this information to make practical and aesthetic decisions about the layout, and in some cases copy may be returned to the writers and editors for compression or expansion.

Page Makeup. Text is organized into pages according to the initial design. If illustrations are to be included in the document, they are inserted at this stage. In fully automated systems, the page layout function may be combined with photocomposition; phototypesetting machines can produce camera-ready pages, automatically laid out according to the initial design. Justification and rules for hyphenation may also be specified.

Typesetting. Many high-quality documents are composed by a computer interface to a phototypesetting machine that will create the reproduction-quality copy. The documents are typeset in the type faces, sizes, and styles specified by the designer, using prescribed line lengths or margins. Other documents are printed on line printers, raster printers, high-quality typewriter terminals, or are typed by hand. Some documents are still typeset using "hot metal" devices (for example, the Linotype machine), and under special circumstances they may be typeset by hand, but these techniques are rapidly becoming outdated.

Illustration

Illustrations include diagrams, flow charts, drawings, and other visual representations that are included in a document or used as a basis for writing. The creation of illustrations is not represented in the flow chart because it may take place at any point during the production process before reproduction.

In manual systems, illustrations are created by staff artists, skilled draftsmen, clerical help, or even by the writers themselves. An author who is not an artist or draftsman typically will create a rough "conceptual" drawing, either alone or in cooperation with a professional artist. The artist uses the conceptual drawing as a guide to produce a more refined, and possibly more specific, illustration that he will submit to the author for comments and approval. This process often entails considerable communication between artist and author to ensure that the final illustration indeed communicates what the author intends. The original illustration may be modified many times before final approval.

When no professional artist is available, a clerical assistant is often asked to create graphs, diagrams, and flow charts with simple tools like pencils, pens, rulers, stencils, and typewriters. If the author is skilled (for example, the engineer who is a draftsman), he will often choose to create a graphical representation of his ideas before beginning to write. He may even use a diagram or flow chart as the basis for a document. In other cases, the writer may not have any input on illustrations. A designer of a brochure, for example, may first create the art work, and the copywriter will produce text to fit into the design.

Listed below are three classes of illustrations, beginning with the simplest and ending with the most complex. The graphical elements they generally include are described for each classification. Most of the elements are shared by all the classifications; some are used primarily for but not necessarily limited to one type of illustrations.

Graphs and Charts. They are used to represent numerical data, such as statistical analyses and budget predictions. These are created with points, lines, curves, colors, textures, and text.

Flow Charts and Diagrams. They are most often used to represent structure and design, whether it be of an electronic circuit, instructions for opening a milk carton, or the information flow in a legal office. They may be as complex as blueprints and architectural and engineering drawings. Flow charts and diagrams are made up of standard geometric figures as well as the basic elements of graphs and charts.

Drawings. They are used to portray many things, including abstract concepts and emotions as well as detailed representations of any object from microbes to galaxies. Backgrounds and free-hand lines are combined with elements used in other types of illustrations to make up a drawing.

Photographs are also included in documents as illustrations. They may be specially commissioned from a photographer for a particular document or produced from existing negatives. Often they must be cropped, enlarged, or reduced in size before they can be integrated into a document. Captions, arrows, and other symbols are added by graphic artists as necessary.

Reproduction

Reproduction is making copies of a document after final approval. In addition to the actual making of copies, the process includes collation, trimming, and binding. In the flow chart, reproduction appears as step 17.

When few copies are required (less than 50), photocopies are often made of the camera-ready copy. When more copies are necessary, reproduction is usually by photo-offset printing.

Reproduction may also take place online. When possible, computer support systems reproduce online files as well as hard copy to make them available for use on other computer systems, for example, through appropriate file translations, transfer of tapes, or network file transfer. Direct output to microfilm without an intervening paper copy is also employed. Direct output simplifies production of documents, such as parts lists, that are distributed via microfilm but never printed. It also allows, for example, the use of type faces and format conventions for microfilm copies that are different from those used for printed copies. A type face that is "readable" in a printed document, for example, does not usually produce easily readable microfilm.

Distribution

Distribution is the process of making available copies of all or part of a document to readers or to information gathering services. In the flow chart, distribution appears as step 19.

In present manual systems, a pile of newly printed documents is physically transported to a list of recipients. The problems with present methods of distribution revolve around the failure of the distributed documents to be integrated into the information-gathering services of the people who need them. For example, documents may not come to the attention of their intended audience or may be miscatalogued by libraries or abstracting services.

The functional document is an important category of technical documents that offers special distribution problems. Functional documents are not defined by their integrity as printed books; they are defined by their title and other bibliographic identification and are designed so that individual pages may be updated, replaced, added, or deleted. Many manuals, parts lists, and reference works are functional documents. Even more documents would be treated as functional documents if it were easier and less expensive to support changes and updates.

Online distribution normally means creating or updating a single computer file that may be read or copied by any system user. The process is inherently much simpler than distribution of manuals or parts lists through the mail. Its simplicity allows much more timely dissemination of information. Online distribution is based on clean and increasingly inexpensive computer technology rather than on the increasingly expensive paper technology.

With distribution, the basic document production cycle is complete: the distributed information is used by other authors as discussed above under Information Gathering to produce new documents.

Communication

Various forms of communication are necessary throughout the document production process. These range from face-to-face conversation to the delivery of the completed document.

Efficient and timely communication is critical for proper control and cost effectiveness. Comprehensive, automated communication tools have seldom, if ever, been integrated into current production systems. President Carter said in a recent interview:

> New ways of using telecommunication--such as telephones linked to computers or video conferencing via satellite--bring the promise of substantial time, money, and energy savings.... The technology is here today. What we need are the institutional mechanisms and commitment in both the public and private sectors to make best use of our assets (Spectrum, 1976).

The control function relies heavily on timely and reliable communication. Transition from one production state to another requires notifying the people concerned. In order to adhere to the schedule, the participants need to be queried and reminded of their individual tasks and

managers must be kept informed of the status of the whole document production project.

Control

The production of technical documents characteristically depends on the cooperation of geographically scattered people to work out many details as the document progresses from one functional center of activity to another. In addition, the production of a single large document often results in many smaller related documents, such as letters, memos, and errata. This complex process always requires a controlling mechanism, which may be either formal and explicit or informal.

The control mechanism ensures that all the necessary components of both the primary and secondary documents exist and that each participant in the production cycle has clearly defined tasks that mesh in time with the schedule of the complete cycle. The mechanism must also ensure the timely transfer of the document and all its components from one stage to the next; for example, from the authors to the editor, from one level of review or approval to the next, and from reproduction to distribution.

In manual systems, this task is accomplished through the use of forms and distribution lists that are attached to documents and their various components, and the use of files that contain the following kinds of information necessary for control.

Personnel. This information includes names, addresses, phone numbers, etc., of all persons associated with the production process, such as the supervisor, production coordinator, authors, editing staff, reviewers, and distribution coordinator.

Catalog. This information includes title, author(s), subject classification, distribution list, key words, indexing, access rights (during and after production), and the relationships to other documents. Information about the relationships to other documents would tell whether the document is new or an update, supplement, or a replacement of a previously released document.

Coordination. This information consists of a detailed schedule for each stage of the cycle and the current state and owner of the document and all its components.

Management. This category might include accounting information, such as what charges have accumulated, what approval signatures are required, and other organization-dependent information.

Format. Most technical documents have their format, typographic style, and layout specified early in the production cycle or even before it begins. This information rarely changes once production starts, and it must be logged and made available to all participants.

Other. This may include justification for the document, review and errata notes, or dates for future revision.

In a computer-based document production system the control function may be automated. An automated control function can gather, classify, record, and maintain data on the production cycle with a minimum of human intervention. The same forms that are attached to documents can be incorporated into this production cycle data base. In cases where most of the workers have online access to the system, the forms may never have to be printed.

The following section describes the computer aids and integrated control and communication tools included in the model document production system.

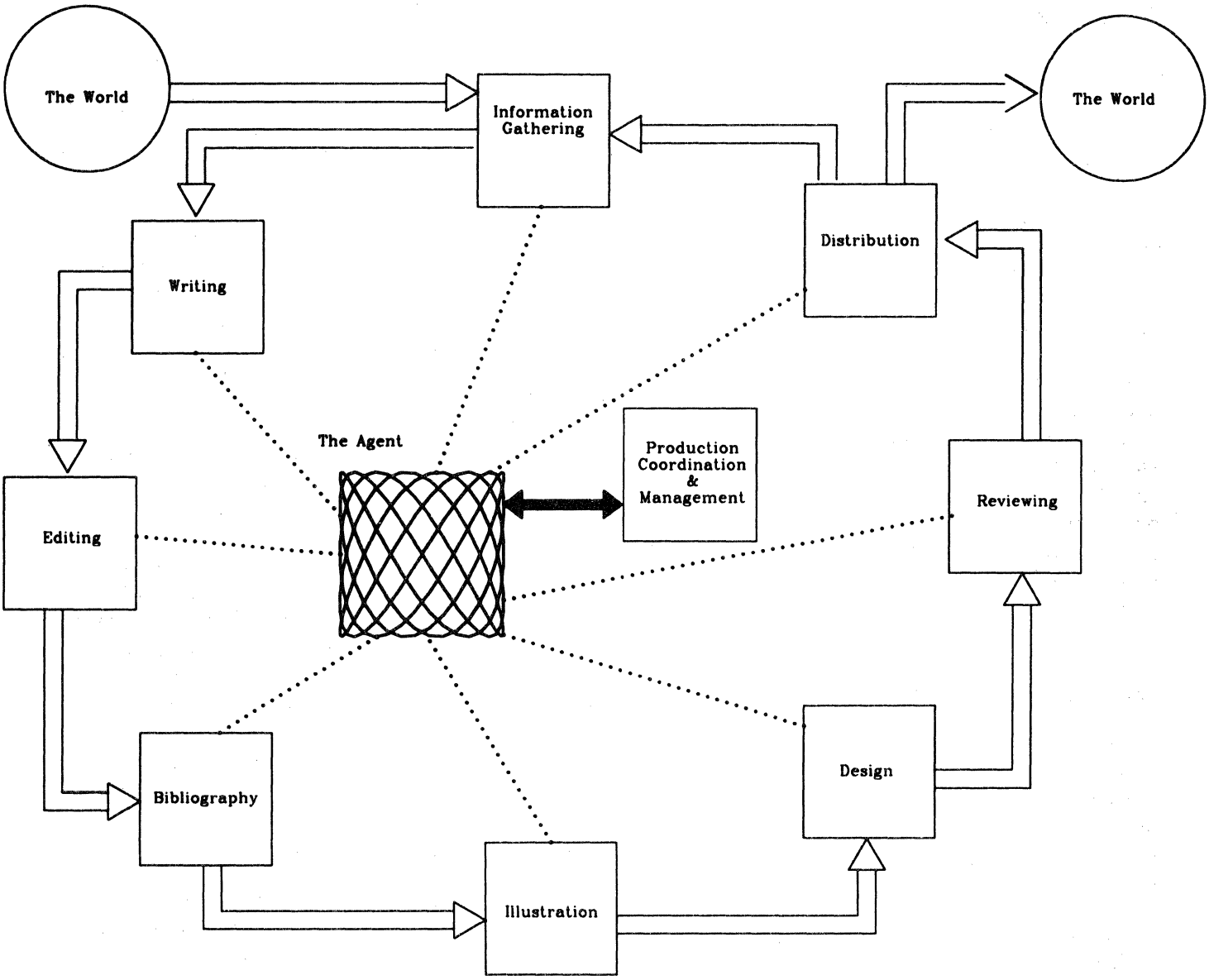
The World
Information Gathering
The World
Writing
Distribution
The Agent
Production Coordination & Management
Editing
Reviewing
Bibliography
Design
Illustration

Figure 2

COMPUTER AIDS

Overall System Reliability and Response

The model system contains a wide range of tools to aid in the production of technical documents. Although the individual tools are designed for specific functions, they are all combined into one integrated system that is dependable, flexible, and easy to learn (see Figure 2). Development, installation, and use of this integrated system will lead to a more economical document production cycle than would the piecemeal purchase and use of unintegrated functional parts. This section describes the overall system features that allow both unsophisticated and experienced users to work comfortably and efficiently.

Reliability

The system is based on a large central computer. With the present and near future state of technology, large computers offer the capabilities we believe are necessary for manipulation of the large files produced in many document production applications. Automated searching, sorting, and formatting are examples of some of these operations currently ineffectively supported on smaller, decentralized systems. This situation is likely to change with the future development of integrated systems based on mini- and micro-processors. The model system design is capable of evolving to take advantage of current technological developments.

Although it is unrealistic to assume that computer processor units never crash, even in the ideal system, our model system will assure that work can continue while the central system is unavailable and that it will be possible to work on files local to the user even if the central file system is inaccessible. The system will provide two major security precautions: file system backup and alternate computer support, either on local processors or on other central systems accessible through communication lines or networks.

The file system design will ensure that no material the user has typed will be lost in hardware or central operating system failure. An automatic backup process copies files to other computers as production deadlines approach. This process, controlled by the Agent (which is described below), will be invisible to the user. Furthermore, the Agent will automatically maintain backup copies of its file control data bases on more than one machine so that work can continue in case of a system failure.

Response

The publications process requires highly interactive computer support. The interaction between computers and users at intelligent terminals will be carefully considered so that users will spend as little time as possible waiting for the computers to perform their operations. A good typist works at a rate of about 80 words per minute; therefore, it is essential for the system user to receive positive response in the form of character feedback for work performed at typing speeds of at least this rate.

Responsiveness is also an issue when the user completes specifications of requests for actions by the system. The mean waiting time for simple operations will be less than two seconds. Users are more willing to accept longer response times when the operations requested are subjectively felt to involve more major processing. In these cases, however, the system will provide positive feedback that it is performing the requested actions. As important as the average response time is the variability of that response. It is more frustrating to deal with a system that has lower average response times with wide variability than to interact with one that is more consistent in its responses to like commands. The standard deviation of response time for simple operations should be half the mean, or about one second (Martin, 1972; Miller, 1968; Winograd, 1975).

These goals will be accomplished through an appropriate mix of local processing capabilities at the users' terminals combined with access to the central computer systems for larger-scale operations. The terminals will have a few hundred pages of local storage for backup and privacy. Input and editing on the level of words and paragraphs will be done locally; larger systems will handle communication, file control, larger-scale editing, and document formatting.

Users should be able to submit jobs for noninteractive processing. Thus, if publication requires formatting a file by an automated process, the user should be able to send that file to the formatter in a background mode and continue working interactively on other tasks, such as editing, until the background job is done.

Computer Cost Versus Labor Cost

Adequate response time is required not only for the comfort of its users: it is not cost effective for an editor to wait around too long while commands are being executed. If the combined cost of the editor's time and the charges for the computer equipment is greater than the cost of the editor's time for doing the same task by hand, the system is not cost-effective.

The trade-offs very quickly become complex because of the interdependence of publications tasks. Consider the following example: With full overhead, an editor costs $12 per hour and an author costs $18 per hour. They may employ either a computer service that costs $18 per hour (with terminals and operator support) or a typist that costs $9 per hour. Manually, the editor can write a comment in the margin in about 30 seconds, and the author can amend it slightly and signify acceptance in 30 seconds. If the correction means retyping one-third of a page and the typist is working from pretty fair copy at three pages an hour, the total cost of making the change manually is $1.25. This means the computer is cost-effective if the commands used by the editor and author take less than about 100 seconds.

This example is grossly oversimplified. The manual system must also bear costs like the transmittal of the draft to the typing pool, logging it in, filing it, and learning to read the author's handwriting. A rigorous cost analysis would also have to consider the cost of the fact that the author's and editor's jottings are available on only one piece of paper. The computer cost is unrealistic because CPU is often charged separately from terminal time. Furthermore, computer charges are often divided into more than just CPU and terminal costs. They may, for instance, include additional costs for file storage. The computer cost must also bear the (very much smaller) cost of the file control operations equivalent to sending the draft to the typing pool, as well as overhead operations such as the prorated logging-in costs of the author and editor.

Our discussion of labor versus computer costs illustrates only some of the problems in meaningfully analyzing cost-effectiveness. The cost of writing the programs to support a function varies according to the software and hardware necessary. The cost-effectiveness of development depends on the specific intended applications and the number of users, as well as the cost-effectiveness of the features themselves. For example, in the case of a technical document that does not include tabular material, the purchase of aids for table editing would not be cost-effective. To take another example, production that involves only short documents of essentially new material (brochures or data sheets) might not require large-scale file searching capabilities.

Because of these complications, system designers and builders must always keep in mind the true costs of the manual systems they are replacing.

User Control and System Feedback

The user can display text on a CRT display screen at any time, either as straight text (in galley form) or formatted as it will be when printed (e.g., with appropriate indenting, headers and footers, and font changes). Filtered views of a document, containing only the set of text entities (such as paragraphs, sentences, and headings) sharing a specified common property, can also be displayed and printed. Filter selection is provided for content and hierarchical structure. Content filters would permit the display of, for example, all sentences containing a given sequence of characters; structural filters would permit the portrayal of those entities at particular levels in the hierarchical format.

The user can divide the screen into arbitrary areas for portrayal of information. These areas, or windows, will be used to display not only textual material, but also graphic material on terminals used for layout design and illustration; special windows will be used to display system information or feedback. It is important that the user be able to control the arrangement of such material on the display screen to personalize the display as needed.

Multiple windows are useful for manipulating information contained in several documents or different parts of the same document simultaneously. For example, the user should be able to copy material from one document into another by pointing at the source material, displayed in one window, and its destination, displayed in another. In the layout phase, multiple windows would be useful for confirming the arrangement of material on pages that would appear beside each other when printed and bound.

The system will also operate on paper-based teletypewriter devices. We assume that the paper-based version will be a secondary working mode employed for reasons of economy and for preserving records of work sessions. This version of the system will resemble, as much as possible, the command language and appearance of the display version, including optional feedback about the user's location by page and line or by structure, and feedback about the current type face.

Command Actions: What the User Can Do

The system includes commands that enable the user to work online using the familiar language of the publications world. The user can repeat any command, once or indefinitely, with minimal retyping. It will generally be possible to undo the effect of the previous command, particularly editing commands. The user can stop a process, such as printing, hyphenation, or spelling checking, at any time. It will also be possible to specify that any command go on in a background mode while the user does other work (if it does do not conflict with that command). Particularly for complex functions or those used infrequently, the system will interrogate the user for the information it needs to execute a command. Thus, if the user wishes, the computer will ask for all the dimensions needed to create the layout of a page.

Objects of Commands

Users will be able to specify the standard parts of documents as the objects of commands, for example, "word" in the command "Delete Word." These entities will include words, sentences, phrases set in special type such as italic, lines, paragraphs, pages, headings, captions, footnotes, equations, lists, and a special set of entities for tables. Organizational units, such as documents (at least to the size of thousands of pages), volumes, chapters and subchapters at any level of organization, and all the paragraphs at a given level of organization, will also be basic operands.

Commands will take effect on any part of the document according to a full addressing scheme. The user will be able to point with a cursor, specify a page and line number if a format has been allocated, specify a place in organizational structure, or specify location by content, by key word, by order with respect to previous changes, by a serial list of entities, and by an arbitrary tag.

Addressing by page and line will include provisions for document elements, such as headers, double or triple column format, and marginal notes. For example, a user will be able to give a command that the second word in the second line of the second column on a particular page be changed.

The user will be able to address by content, giving a command to the system to display or change the text that contains a certain string of characters. This search will locate text specifically before or after the page currently viewed, or without regard to present location. When specifying content, the user will be able to include ellipses, optionally ignore case, and include the logical functions NOT, OR, and AND. For example, he will be able to delete the next paragraph in the document containing the statement "Man bites...dog" but not the phrase "Help!"

In general, technical documentation has a complex hierarchical structure of volumes, chapters, paragraphs, subparagraphs, and so on. The user will be able to address any text entity by specifying its position in the hierarchical outline of the document. Since page and structural addresses change as a document develops, the user will also be able to specify a unique, unchanging serial reference number that the system will automatically assign to each paragraph or heading as it is typed or copied into the file.

Since page breaks are determined by the format in effect over any document, they will vary widely in the number of words they contain. This number will commonly vary between 250 and 1000 words. For the user to be able to define pages of any length, the system must not impose arbitrary computer boundaries. Documents will be available in paged form, but the user will be able to work easily across pages as well as files.

Command Style

Because there are many functions in document production, the system will recognize many commands. To help users focus on the tasks they need to accomplish, it will be

possible to group commands into functional groups (subsystems) available to the users as units. Individual publications departments and users can rearrange these groups for their particular needs; for example, an input typist might require only a few basic commands to manipulate text while an editor requires both basic and sophisticated editing commands.

To allow for the varied background and for naive users, commands will provide substantial feedback information (for example, "DW" would cause "Delete Word at" to appear on the users display). However, experienced users can specify the amount of feedback, if any, that they want. It will be possible to specify commands by typing varying amounts of the command name, from minimal specifications (such as, "DW" to instruct the system to delete a word) through spelling out of the entire command phrase. It will also be possible to attach commands to function buttons on various keyboards. For example, it would be possible to hit a "Delete Word" key to delete a word.

Help Facilities

Users need two major types of help concerning commands: syntactic information describing the proper form of commands, and semantic information describing their results.

There will be several levels of syntactic information available. The system will inform the user of the options available at each stage in a command. This type of help will range from the presentation of simple prompts to the complete listing of possible options.

Automatic tutorial and question-answering features will be included to provide semantic information. These features will be particularly useful for people working on shared files at a distance from system trainers and consultants.

Recording What Has Been Done

It is frequently important for a user to know when and in what order sections of a document have been changed. To provide this information, the time the last change was made will be recorded for every page, heading, and paragraph. The user will have the option of viewing or not viewing this information, and will be able to display or alter the most recently changed paragraph (or any other entity), any entity changed since a certain date, and the like. The identity of the last person who made a change will also be recorded and available as an address. The existence of this information will be useful to the Agent discussed below. A record of recent deletions will also be maintained. This will be useful in the development of an "undo" facility.

The Work Station

The "ideal" work station configuration depends on the principal tasks to be performed. A clerical assistant, whose main task is to enter online author's hand-written notes, needs different equipment than a graphic artist who creates technical illustrations. The needs of individual organizations also vary; the types and numbers of documents produced will determine which equipment is most efficient and cost effective. Described below is the equipment to be included in a complete work station that would provide access to all the document production capabilities described in this report, from simple reading and writing to complex illustration and document design. Attention is also given to the working environment, the physical setting in which the work station is placed.

Equipment

Television-like display devices will be the primary terminals used in document production environments. Typewriter-like devices and other printing machines are needed only to provide paper versions of material to be viewed offline or for reasons of economy. Ideally, any publications group

will be equipped with at least one display work station that is large enough to portray full pages as well as four lines for feedback. Along with the standard alphabet, this display will represent traditional special characters (for example, the Greek alphabet, common mathematical symbols such as integration signs, and sub- and superscripts).

Display must have sufficient resolution to differentiate clearly among standard classes of fonts (for example, italic, serif, and sans serif), and a range of at least 30 percent in the number of characters at the same point size that can fit into a linear inch is necessary. Larger displays provide on the order of 140 lines by 170 columns for displaying basic text, which accommodates two pages of legal sized material and has room for system feedback information. Such a display would be useful for the Blue Pencil editor discussed below and for creating and editing tabular material, layouts, and illustrations.

The work station for the clerical staff will permit rapid bulk input of material, both by keyboard and by optical character recognition. Keyboard input by these users requires immediate feedback for typing speeds to 100 words per minute. In this context, local processing and capture of input in dedicated devices with storage media such as floppy disc or cassette may be most efficient. Material entered in such a manner may then be transferred to the central system.

The work station for authors and editors has different requirements from those of clerks. Whereas the need for rapid feedback of input information is less for these users than for clerks with high typing speeds, the portrayal requirements are greater. How a document is portrayed while it is being created and edited affects its ultimate content and clarity. These users require display terminals with screens large enough to permit presentation of at least a full page of material in multiple fonts and with the ability to include and display graphical material. In the context of technical documentation, a "full page" should consist of a grid of at least 66 lines of 85 characters each, although the capability to display a larger page would certainly be useful. The user will be able to display any text at any time, either as straight text (in galley form) or formatted as it will be when printed, with appropriate indenting, headers and footers, change of font for special text, and other format elements.

For editing purposes, color will be used to clarify differences between original material and suggested edits. Display editing facilities will be provided with appropriate devices for text selection, such as a mouse (English, et al., 1967), and for graphical manipulation, such as a lightpen.

Terminals that display less than 70 lines could still be useful for viewing full-page formats with the use of additional software devices. To enable the user to view page images larger than the screen, it will be possible to scroll the page up, down, left, and right. Feedback displayed on the screen keeps the user informed of the page and line number currently displayed and the type face of the displayed text. Terminals that lack the resolution to display different type faces will emphasize the text that is the object of searching or editing commands with at least two types of highlighting (for example, brightening and reverse image).

For the development of illustrations and layout, a large, flat display screen on the order of three by four feet that can be adjusted like a drafting table is desirable. Because CRT screens will not represent colors accurately, a color sample chart will be provided that shows standard colors. A small, lightweight, wireless pointer/cursor control will used to indicate the drawing of illustrations. It will also be used as an electronic "paint brush" with the width of the brush strokes controlled by the user. To enable content review by writers or editors, any standard text-editing CRT display will provide a rough black-and-white approximation of illustrations. For the pro-

duction of camera-ready copy, the system will interface to a multicolor, mixed text and graphics printing device.

A work station that permits the portrayal of both text and other material on a single full-size screen is extremely desirable. In the near future, this will be possible through video mixing of images from an alphanumeric terminal and photographic images stored on film media such as computer- controlled fiche. Of greater long-term potential will be the development of digital image technologies. Graphics and photographs have been experimentally incorporated into single-screen work station portrayals through the use of digitized images that can be manipulated similarly to textual material. The graphic material may be entered into such systems via digitizers that resemble current xerographic copying devices. This technology is especially valuable in the layout phase, but would be useful in all phases of document production.

Current technology often requires compromises in the portrayal of mixed text and graphics. Terminals used for text editing are generally suited only to the portrayal of alphanumeric material. Low cost justifies this limitation. Line drawings and text with multiple fonts require terminals with greater portrayal capabilities and hence greater cost. Currently, work stations that attempt to satisfy conflicting needs often make use of more than one physical display terminal; typically a low-cost, high-speed alphanumeric terminal is used with a higher-cost storage tube graphic display suited to the portrayal of line drawings.

High-quality camera-ready copy of text produced by the system must be readily available. Current hard-copy devices range from low-cost, single-font impact printers incapable of printing drawings or photographs to highly flexible xerographic printers capable of producing high-quality digitized images of graphics with mixed-font text on both sides of dry paper at high speed. Impact printers are available in high-speed models that produce hard copy of varying quality and in lower-speed models that can be used as communicating typewriter terminals and have interchangeable print elements or fixed typewriter hammer elements. Other types of printer technologies make use thermally sensitive paper and a print head that produces characters by heating areas on the paper, devices that spray jets of ink on a page, and other mechanisms that make use of other types of specially treated material.

All these printing devices have similar disadvantages: they are often extremely noisy, it is difficult or impossible to produce multi-font material, and graphics may only be simulated. Although camera-ready copy can be produced using high-quality impact printers, more often than not intermediate paste-up jobs are required. Also, the quality of many of the currently available mechanical printers is very low. Computer Output to Microfilm (COM) devices and related photocomposition and xerographic printer devices eliminate many of the qualitative disadvantages of the other printers. They are currently very expensive, but they can be expected to drop in price.

Slow response from the terminal, commands without coherence in grammar and vocabulary, and insulting error indications may irreparably antagonize users. Therefore, frequently used tools will operate in small computers close to the work stations or built into them to provide quick response desirable for publications, but work stations will be able to call on more specialized or sophisticated processing systems through communication networks (Martin, 1972; Miller, 1968).

This division of functions takes advantage of the economies of scale available when the costs of large, expensive facilities such as mass file storage or large data base systems are shared among many users. Communication facilities also permit geographically distributed collaboration. The local processor will provide access to several hundred pages of local storage, whichhis may be through floppy discs or a similar medium. Material may be copied or written on the central

data stores as necessary, but such configurations will permit the user to do most of his or her work on a dedicated, truly reactive system.

The Working Environment

The physical setting of document production is critical to the effective use of new technologies. Human engineering of the hardware and provisions for incorporating the devices into the users' offices influence acceptance of systems. Such considerations are fairly common in industrial settings and in standard office landscapes, but comparatively little research has been done in the United States on the use of computer work stations in the offices of nontechnical workers.

In Sweden, much attention has been devoted to the problems of computerization of offices (Ostberg, 1975, 1976; Hultgren and Knave, 1974). Workers' committees may reject terminal configurations that do not satisfy human factors requirements. Recent Swedish research that has uncovered particular postural and visual problems associated with work stations is applicable to the document production environments we envision.

Ostberg reports that typical working postures at terminals have the following negative features:

"- raised arms due to high mounted keyboard

- raised neck and gaze due to high mounted display screen

- faulty posture due to requirements imposed by the handling of the documents

- faulty posture due to requirements imposed by the handling of the terminal" (Ostberg, 1976).

These faults, which may result in back problemsmuscle strains, and general fatigue, can be avoided through proper workplace design.

Lighting is a critical factor when using a video display, particularly when simultaneous reading of printed copy is required. Past experiences with display devices in office environments suggest that visual problems arise from glare and reflections, long viewing distances due to inflexible work stations, unclear character generation, and image flicker. Poor lighting can seriously hinder performance and can eventually result in permanent damage to the user's eyes (Ostberg, 1975).

Work done with dark terminal screens in light offices may be disturbed by both glare and reflections on the screen (Hultgren and Knave, 1974). Workers' attention must shift alternately among keyboard, screen, and hard copy working material. Lighting appropriate for hardcopy presents too much glare for viewing CRT display screens; conversely,the darkness appropriate for viewing the screen may introduce fatigue when reading other material. Possible solutions to these problems include the use of room dividers to block reflections from windows; the use of individual, aimable lights at each work station in place of uncontrollable ceiling lighting; display work stations with adjustable screen positioning; and the development of new display media with opaque, nonglowing surfaces. It is also important that the text on terminal screens be legible to avoid operator fatigue.

Some terminals are noisier than others. Current high-speed impact printers are extremely noisy, display terminals tend to be relatively quiet, and the various typewriter terminals lie between them on a noise spectrum. In spite of their relative quiet, however, most display work stations have fans that produce an irritating hum, and the CRT may emit high-pitched sounds that are uncomfortable to users. Current literature tends to be somewhat sketchy on the desirable noise level in an office environment (McCormick, 1970; Woodson, 1960). However, there seems to be general agreement that noise degrades work, particularly in vigilance tasks, tasks requiring skill and speed, and complex mental tasks. Activities of these types are routinely required in the

document production process. Terminal noise may also contribute to psychological stress and fatigue.

The noise level of a user's own terminal may be more tolerable than the noise generated by other terminals in the environment. Also, the collective noise of groups of terminals may be more stressful than the noise of a single terminal when the noise level exceeds a tolerable threshold. Noises in terminal areas may be dampened by acoustic ceilings, carpets, and dividers to minimize the fatiguing effects of terminal fans or printers. Noisy printers should be located in separate rooms. Separating terminals from each other and from other office functions may minimize distractions, but is not necessarily the best solution; the separation may deprive the group of the desirable interactions derived from clustering the terminals of people involved in similar tasks.

The work station table itself should provide enough room for the terminal (display or typewriter), for all hard-copy materials needed in the users' tasks, and for other hardware such as cursor control devices and telephones. It should be adjustable in several dimensions: for example, the position of the keyboard and of the display should be easily and separately adjustable for height, distance, and tilt for the visual comfort of the user. The chair should provide the lower back support needed for long sessions in front of the terminal.

Nontechnical personnel should not use terminals in the same room with a large computer system. This restriction may be relaxed as more powerful processors and memories become available in smaller configurations. The goal is to avoid a perceived threat due to the physical presence of an exotic machine. The user should be removed from the noise generated by the machine and the special temperature requirements necessary for its maintenance. Users should, however, have easy access to the printing facilities they need.

In general, considering the cost of computer support to gain increases in performance, attention should be given to maximizing that gain through a humane environment.

File System

A well-designed file system is crucial to the effectiveness of a computer-based document production system. To provide a wide range of capabilities and allow the user to work comfortably and efficiently, the file system must provide the following features:

Limitless Document Size

There should appear to be no limit on the size of a document to a user. There are many possible technical means to allow users to view or edit documents even though they are larger than available core.

Hierarchic Structure

Traditionally, large technical documents are hierarchically organized. The file system will facilitate writing, editing, and viewing the intrinsic structure of these documents by presenting filtered and outline form views of their content. Optimal structure will result in responsive search, portrayal, and editing capabilities; adequate system reponse depends on the organization of files. Some current online editors have file systems that require repeated traversal of the entire contents of a file in core in order to perform the simplest operations; this traversal often leads to unresponsive interactions.

Reliability and Security

The file system will provide insurance against loss of work through hardware and software failure as well as protection against unauthorized access by other users.

Support for Collaboration

Document production is often a collaborative effort by writers, editors, clerks, layout designers, and others. The file system must permit these workers to interact and create efficiently without interfering with each other.

Capability for Evolving

The set of computer aids must be able to evolve with changing needs and technology. The file system must be sufficiently general and flexible to allow this evolution to take place without major changes in design.

There are a number of concepts and features associated with well-designed systems that are necessary to support the capabilities listed above: structure, security, indices, numbering, nontextual data, and audit trail.

Structure

Searching is aided by the ability to restrict searches to user-defined levels in the structure. Complex formatting is made much easier because formats can be associated with structural entities or levels. Structured files add much power to the editing functions by allowing changes to be made on structural entities (for example, a paragraph or hierarchically related collection of paragraphs) as well as on textual entities (character or word).

Two design considerations that are important for a document production system are: (1) that there be virtually no limit on the size of a document, and (2) that time required for most operations on a file should be independent of the file length. A randomly-organized, indexed file system will make these features possible.

Structuring systems range in complexity from relatively simple hierarchies, or tree-structured files, to highly complex graph structures required for efficient performance in special applications such as those operating on massive data bases. Tree-structured systems are better for a general-purpose document production system because they are more powerful than sequential systems, and are conceptually simpler and easier to maintain than the more general graph-structured systems.

Security

The system must provide adequate protection against both accidental and deliberate misuse of information by users and by the hardware and software systems themselves. At the same time, these protections should not interfere when groups of people are working together on the same document. Some design features that have been found effective are listed below.

1. Minimizing the times of high vulnerability to hardware or software failures. One technique is to write small sections of text to a disk as soon as a change has been made in the core image. A second is to record changes in a separate file, merging them to a new version of the original at the user's command.

2. Controlling access to files by members of the collaborative group. The system could permit multiple simultaneous readers for a file but should not allow multiple writers except under specific, controlled circumstances. This solution maximizes access while minimizing vulnerability to loss of work.

3. Permitting personal establishment of access to files by other system users. The owner of a file should be able to specify read or write access to the file for the owner alone, for a particular group of people, or for everyone.

4. Where multiple copies of a file may exist in a distributed processing environment, perhaps with copies of files maintained on local media at the individual work station, a central control system must be responsible for maintenance and coordination of all files in the system.

5. Providing prompt archival and retrieval services. Utility systems and sound operational procedures for their use should be available for archiving of files not in active use, for their rapid retrieval when they are needed, and for making copies, on a regular basis, of all online file storage devices.

Indices

Even with highly structured files, some form of indexing is necessary to perform rapid searches and retrievals over large documents. Though many indexing schemes, such as file inversion, have been conceived, none is optimal for all possible applications. Therefore, the file design should provide at least a relatively simple key word indexing system and allow the construction of more complex user specified indices.

Numbering

Two kinds of paragraph identifiers are useful. First, and most commonly used in line-oriented systems, is a sequentially assigned permanent number that is independent of structure and does not change unless the user explicitly renumbers the file. This type is most useful when a document is being edited online from a marked up hard-copy printout. Second, and less common, is a dynamically assigned identifier that describes the position of the paragraph in the file structure.

Nontextual Data

The file design should be sufficiently general to permit storage of data other than text in the file. An expensive part of the document production process involves collating illustrations, for example, with the text and inserting them in the proper place. The process is much simpler if the illustrations are stored in the proper place in the file at the time of their creation.

Storage of nontextual data and special categories of text allows the inclusion of formatting codes and editorial comments, which could be displayed when desired by the user. This allows viewing the file as it would appear in final format without interfering formatting codes or editing marks.

Audit Trail

The revision and editing process is made much more efficient if editors need only read those sections that have been changed since a certain time. The file system will provide for storing the date of the last change in each paragraph. A record of at least the two most recent changes and the person who made the change must be maintained.

More difficult, but sometimes essential, is keeping a record of recently deleted paragraphs. Some systems do this by marking a record deleted but not releasing its space. This strategy very quickly produces files that are so large as to be unmanageable. However, some compromise could be designed.

To summarize, the file system should offer hierarchically structured files that permit random access by key word indices. The system should provide for file integrity, alternative indexing algorithms, nontextual data, fixed and structure-related paragraph numbers, and a record of previous changes.

Information Gathering and Writing Tools

Two basic functions aided by the ideal computer-based document production system are researching and writing. To allow for the many different ways researchers and authors prefer to work and to provide for the wide range in their online working experience, the system provides several alternatives for online information gathering and composition. The simplest method allows an inexperienced user to sit down at a terminal and read or write; the more complex methods enable the sophisticated user to take advantage of flexible text-handling tools and the interactive environment.

Information Gathering

Information gathering ranges from straightforward reading to employing computer-based aids to thoroughly search catalogs and documents for specific information. A simple reading mode allows the user to read or skim text at any speed. A signal from the user will cause the next page of text to be rapidly displayed, and a few basic commands allow the user to skip backward and forward through a document. The user always has the option of printing, for offline reading, anything displayed on the screen. A batch facility allows the printing of long documents without tying up a terminal. More sophisticated tools provide various "filtered" versions of a document for display or printing.

Filters. To facilitate reading as well as searching through documents for relevant or interesting information, the user may specify one view or a combination of several different views of any document or group of documents. The system will filter out to display or print only those sections that meet the user's search criteria, which may include hierarchical structure, key words, content, author, date, subject, illustrations, and tables. For example, the user may choose to see only a basic outline of a document, only those abstracts that contain a specified word, or only articles on a particular subject written after 1973.

Catalogs. Online catalogs provide the user with the information such as the following for online and offline documents: author, title, date and place of publication, abstract, and key word list. The Agent, described below, automatically collects relevant data on in-house publications and, upon their official release, creates appropriate catalog entries. Users can easily create catalog citations for any online documents, memos, or notes, or any offline documents. The user can scan through the catalogs, just as through library card catalogs, or can use an automatic searching facility that will list the documents that meet the search criteria. For example, the user might request a list of all 1976-1977 documents available on diamond prices. A batch option, which searches in the background, allows the user to request that a list of references be provided at a specified time. The user also has the option of specifying that only current online sources, or archived sources as well as online sources, be searched. The system can provide full text retrieval, abstracts, or bibliographic citations.

The filter described above can be combined with the searching facility. The searching facility will locate those documents that meet the user's criteria and provide "filtered" versions of them, for example, an outline view of all relevant documents or abstracts only. A researcher can use these tools to compile a document automatically. For instance, he or she could request that a document be printed containing the paragraphs that mention cucumbers in the online documents that meet the search criteria.

The system should provide access and a consistent user interface to the rapidly growing collection of specialized computer-based catalog and abstract systems covering a wide array of intellectual disciplines.

Links Between Online Documents. The user can insert references to other online files anywhere in a document. This reference not only is information for the reader, but it provides an online "link" between the document with the reference and the document that is cited. Any user can get access to the cited document by typing the reference or by simply pointing to it with a pointing device, subject to protection restrictions. The exact material cited in the reference will be displayed on the user's screen.

The user can also instruct the system to scan a document for references to other documents, and then create a corresponding cross reference in the cited document. This capability will help future researchers find relevant documents easily. Every document will not only contain references to its

sources or other pertinent documents, it will also cite any documents that reference it as a source or as pertinent. Older documents will be kept up to date by containing references to documents that have expanded on or clarified their major topics. These "back links" are optionally visible to the reader and do not permanently alter the text or page layout of the document in which they are included.

Writing

The user has the choice of two different writing modes: a "type-in" mode for straightforward typing and a "fill-in" mode for composing. The type-in mode has very simple commands for typing by unsophisticated users, for example, a typist transcribing a tape or a writer who doesn't often use the system. As the user types, the terminal screen will automatically scroll to show what the user is typing. A few basic editing functions, such as backspace character, backspace word, and backspace sentence, will allow the user to correct typographical errors or make minor edits as he or she types. After typing a paragraph or section, the user may instruct the system to incorporate it into the document without changing what is displayed on the screen. Then he or she can simply continue typing the next paragraph.

The fill-in mode takes advantage of the interactive environment and sophisticated editing commands (as described in the section on editing). The user is free to discover an individual style of online composition, whatever feels the most comfortable and is the most effective. He or she may choose to create an outline to fill out, look at different filtered views of the document, move paragraphs and sections around, copy from other documents, or combine any or all of the many methods for inserting and editing text.

The ability to copy easily from any online document to any other document, or from one section of a document to another, will greatly assist in rewriting, reorganizing, and updating documents. Any textual entity, from a single character to an entire document, can be copied from any document to which the user has access rights.

All the retrieval and filtering tools for research described above can be used for copying. It is always possible to copy into any document whatever appears on the display screen. For example, the user can copy from a source document only the paragraphs mentioning a certain subject or only the headings down to a certain level. He or she can also copy the material cited in a reference, that is, in the "linked to" document, by typing in the reference or by pointing. It is possible, in fact, to compile an entire document solely through the use of references to other documents. When the user wishes to view or print this "compiled" document, the system will automatically follow all the links and display or copy all the relevant paragraphs.

Many technical documents include information generated in a data-processing environment. Examples include status reports to management or to clients requiring revenue or cost data, and scientific studies requiring statistical analyses. The document production system will allow writers access to this information in text form and will provide an interface to material generated by available analytic software systems (for example, SPSS) much as it does to material generated by cataloging systems. Most often this information is organized in the document in tabular form. Tools will be available for automatic entry of tabular material from other systems and for easy keyboarding and correction of new tabular material.

Material on other computers may be accessed through communication networks for incorporation into documents being created. Where no direct links exist, this material may be recorded on electronic storage media such as tape, disc, or cassette for shipment to the researcher's host computer. Documents available only in hard copy may be captured into online form through the use of optical character recognition (OCR) devices.

Special input commands for tables will enable the user simply to type in entries; the system will automatically allocate them to rows and columns according to a predefined format. The user will be able to design a format or choose one of several standards. Columns can be right, left, center, or decimally justified, and the system will rejustify content if a cell is changed. All of the searching, copying, and filtering capabilities described above can be used for locating, reading, or creating tables.

Multiple Windows and Multiple Display Work Stations

To make comparative reading and copying from source documents to notes or working drafts easy, the user can divide the screen into two or more sections. These "windows" can be used to display different documents or different sections from one document at the same time. More than one display screen can be used at the same time for viewing or copying, and the user can command all of them from the same keyboard.

Editing Tools

When users begin to write most or all of their documents with a document production system and as they collect a reserve of online documents, effective editing tools become vital because more information is copied and rewritten than is typed in or written from scratch. Editing tools are used not only to correct a current document, but to rewrite an out-of-date document or create a new document by combining and modifying sections from several existing ones. The ideal editing system provides tools to aid the entire range of editing functions, from basic punctuation and spelling correction to complete reorganization and rewriting of documents.

Capabilities

To modify and reorganize text, an editor is provided with easy interactive commands to type in, delete, replace, move, and copy text, and to copy, delete, move, replace, combine, and divide larger organizational units such as paragraphs and chapters. The entities that can be manipulated with these editing commands include: words, sentences, phrases set in special type such as italic, lines, paragraphs, pages, headings, captions, footnotes, equations, lists, and a special set of entities for tables. Organizational units, such as documents (at least to the size of thousands of pages), volumes, chapters and sub-chapters at any level of organization, and all the paragraphs at a given level of organization can also be manipulated with editing commands. For visual emphasis, the system will highlight text that is the object of editing or searching commands in at least two ways of the editor's choosing, for example, brightening and reverse image.

All editing commands will address any part of the document according to the full addressing scheme described above in the "User Control and System Feedback" section. These addressing methods include pointing with a pointing device; specifying a place in organizational structure; specifying location by content, by key word, by order with respect to previous changes, and by a serial list of entities; and typing in a page and line number if a format has been allocated. Addressing by page and line will include provisions for document elements, such as headers, double or triple column format, and marginal notes. For example, an editor will be able to give a command that the second word in the second line of the second column on a particular page be changed. Additionally, an editor can tag any location in a document as working reference--to slip on a plastic clip, as it were. This mark can be the object of a rapid search and optionally be invisible when the file is displayed.

To view and manipulate the overall organization of the document, the editor will be able to display and print filtered versions of a document, containing only the set of text entities (such as paragraphs, sentences, and headings) that share a specified common

property. Filter selection will be possible for both content (for example, show all sentences containing given text) and structure (show first level headings only). Thus, it is easy to reorganize a document. By displaying a view of chapter heads only, the editor can move and transpose the headings and any text associated with them (structurally "below" the headings). It will also be possible to specify that any editing command take effect only on the content that passes a filter. This will enable the editor, for example, to replace a specified word in only those paragraphs containing certain text or in only headings at a certain level.

The editor will not be troubled with the boundaries sometimes created by the computer's processing functions. For example, it will be possible to address a document without regard to computer "files" and without knowing about units such as "records."

It is frequently important for an editor to know when and in what order sections of a document have been changed. To provide this information, the time of the last change made will be recorded on every page, heading, and paragraph. The user will have the option to view or not to view this information, and will be able to use the filter capability to display or alter, for example, the most recently changed paragraph or any paragraph changed since a certain date. The identity of the last two or three people who made a change will also be recorded and available as an address.

To integrate form and content, and for experimental examination of formats, an editor will be able to instruct the system at any time to lay out the current draft into pages as defined by a selected format. If anyone later changes the text in a way that affects the allocation of text into lines or pages, the system will reallocate all lines to pages in the background.

Repetitive Editing

To make repetitive editing tasks more efficient, correction of technical errors, such as punctuation and spelling, will be allocated to the computer, and the editor will intervene only when intelligent choices are necessary. Mechanical editing functions, such as checking spelling or correcting the spacing around punctuation, will also be allocated to the computer, optionally in the background. Spelling, grammar, and punctuation rules may vary from one institution to another and often from one user to another, and it will be possible for editors to modify the rules of the mechanical correction procedures.

The user can specify that any appropriate command or part of a command continue to repeat automatically until he or she stops it. For example, if the numbers were recalculated in a table, the editor could repeat the Replace command and then simply point to each entry that needs to be changed and type in the correct one. Optionally, it is possible to repeat the command except for specification of address, allowing the editor to insert a new address but retain all the other elements in the command.

With one command, the user can replace a character, a word, a piece of text, or any text entity with another throughout an entire document or through any specified part of it. The definition of "a piece of text" includes the ellipses and logical operators defined in connection with addressing and does not regard the boundaries of entities. The command will operate over all occurrences of the text in the part of the document the editor defines, or on a certain number of successive occurrences of the text, or will display each new instance one by one so the editor can make a decision for each individual case. The user can make these "global" replacements on a filtered document; the substitutions will take place only on those sections of text that pass through the filter. If the user wishes, the system will display, one by one, each occurrence of the text entity to be re-

placed. The user will then have the option of making the substitution for each entity on a case-by-case basis.

Tabular Material

In addition to the standard text entities described above, the editor can use editing commands to manipulate special table entities: rows, columns, and cells; headings and subheadings with the columns they control; and side heads with the rows that they control. The editor can right, left, center, or decimally justify columns with a single command, and the system will automatically justify the content if a cell is changed. The ability to scroll up, down, and sideways over a page image larger than the screen will assist the user in editing tables.

Illustrations

An editor does not normally create or alter llustrations. Therefore, the creation and editing of graphics are not discussed in this section. (See the section on illustrations below.) However, an editor does review the appropriateness of graphics and their integration into the document, functional effectiveness, appropriateness and correctness of captions, page layout, and lists of illustrations. The editor, therefore, is provided with search and display tools to find graphic entities, and the tools for structure and content searching to locate text that is part of an illustration. Text editing commands, global substitutions, and automated editing described above will treat text within illustrations, such as labels and captions, like any other text in the document.

A Blue Pencil Editor

The traditional editor's use of blue pencil marks, or the equivalent, is one of the most important methods of communication in document production, serving two important functions. The marks control the "view" of the text so that any reader may differentiate the current text from the editor's or reviewer's ideas, and they serve as an economical means of instruction to typists. A computer-based Blue Pencil Editing System will allow these functions to be performed at a display and eliminate retyping to incorporate the editor's suggested changes. To use it, an editor will load the file to be edited and enter comments, corrections, and proof-reading marks as she reads. These comments and corrections will be reviewed by the author, and will become permanently incorporated into the document only if he or she approves them.

The Blue Pencil Editing System will display the editor's corrections in a distinctive way, for example, with special delimiters, using highlighted or reversed display, or by setting them off in location, so they will stand out from the text of the document. A list of standard symbols the editor might use to indicate corrections will be provided, and the editor will be able to define new symbols to add to the list or modify any of those already included. The editor can also suggest complete rewrites of sentences, paragraphs, or entire pages and indicate exactly where in the document they should go. The author will be able to review the editor's suggestions on a full-page display, print the file on a line printer for offline perusal, or work at a typewriter terminal.

The user can view or print any document that contains editorial suggestions in at least three ways:

As if the suggestions were not there.

Showing and clearly identifying the proofreader's marks only.

Showing and clearly identifying both proofreader's marks and the longer notes editors commonly make in the margins or on attached sheets.

When the author reviews a document to decide which changes to keep and which to ignore, the system will allow the author to scan the file online and point to the edits he or she would like to be incorporated permanently. For example, if the editor has indicated that a paragraph should begin

at a certain point and the author concurs, the author will give a command to incorporate the change into the document and specify the paragraph mark by address or with a pointing device. The system will then break the paragraph at the indicated point, creating a new paragraph. The user will also have the option of simply requesting that all the edits be automatically incorporated or ignored in any section, in any group of sections, or through an entire document.

To control who can change what and when, the Blue Pencil Editing System will have appropriate interlocks with the Agent, discussed below, to allow review and editing only at the proper time by the proper people. Because blue pencilings are sometimes of historical interest, the blue pencil version of any document, as well as the improved version that results from implementing the changes, can be easily stored and retrieved.

Illustration Tools

The ideal illustration system contains tools to create, modify, print, and store graphical representations that are easily integrated into online documents. A simple set of illustration "entities," called a template, is provided for the unsophisticated user. It includes lines, predefined figures, background, texture, color, blank space, and text that can all be easily manipulated by any user, including writers, editors, clerical assistants, and managers. On the other hand, the sophisticated user or professional artist is provided with a flexible set of tools with which to freely design and illustrate. The illustration system will interface smoothly with the editing and layout systems described above. Together these systems provide the tools necessary for combining text and graphics to create a high-quality document.

Capabilities

Template. A menu of "figures" can be specified by name or by pointing. The templates are prototypes, and the system automatically determines the proportions for a figure to fit it into a specified area. Default templates, designed for the individual organization, are available and may be easily modified. New figures may be added by individual users to the menu at any time. Any area on the screen may be defined to display any or all menu elements. The system will automatically fit the menu elements into the template area. The width or style (such as dotted and dashed) of any line or group of lines in the figures may be set or changed at any time. The system will also automatically repeat a figure within a user-supplied pattern and lay out figures equidistantly.

Dynamic Flowcharting. A special capability is provided for the easy creation and modification of flow charts. When a figure is moved in the chart, the system will redistribute the other elements correspondingly. For example, when a box is moved in a chart, the lines incident to the box will be adjusted to ensure that the box remains connected to the other figures in the chart. The system also automatically redistributes flow chart elements to prevent line crossings.

Freehand Drawing. In addition to template and point-to-point drawing capabilities, the illustration system also provides aid to freehand drawing. A freehand line can be drawn in any width or style, with no restriction on its length or direction.

Texture. Textures, such as patterns of dots or series of crisscrossing lines, are supplied by the system for special effects. A sample "swatch" that the system will repeat to fill in any defined area may be created by the user. The system can also create a "random" texture. Textures may be treated as menu items, and any figure may be "filled in," either with solid color, texture, or background.

Background. The system provides backgrounds for images, controlling the contrast between the background and the image. Besides standard backgrounds, such as graph paper and solid color, the user can

design a background by creating a sample "swatch," which the system will repeat to fill in any defined space. Figures, textures, freehand drawings, or any combination of the above may also be used as background. For example, the user could create a large, light-colored logo. A simple command will create a reverse image: the background will have the color and/or texture of the image, and the image will have the color and/or texture of the background. Any background can be defined as a menu element.

Color. Many technical documents do not use color. Therefore, the illustration system provides a choice of black and white, shades of gray, or any range of color. A color may be specified by name or by pointing for any entity, including lines, menu figures, backgrounds, textures, any "region," and text. The system supplies a standard menu of colors, and the user can "zoom in" to see or specify further detail in the range between two neighboring colors. Colors may be modified and new colors created by manipulating hue and saturation or simply by "mixing" two or more colors. The new color can be included in a menu or used once to color an entity.

Typography. Text associated with illustrations can be manipulated as a graphics entity, including all of the appropriate typesetting capabilities and elements specified in the layout section. The copyfitting capability is extremely useful for illustrations. If the user supplies text and chooses a type face, the system will determine the necessary type size and fit the text into any specified area.

Text can be typed in directly at the keyboard or copied from any document in the system for insertion in an illustration. The text editing functions described in the section on editing enable the user to correct or modify the text.

Creating and Editing Illustrations

The user can create an illustration in its actual place in a document, or can create it separately so it can both be integrated into any document or be printed by itself. The illustration or any group of illustrations will be named for easy storage and retrieval. Existing illustrations can be edited or modified using all the capabilities described above.

As the illustrator works, the graphics display screen can arbitrarily be divided into areas for drawing or creating an illustration and areas that contain template entities, including figures, colors, and textures that the user can copy into the illustration. Another area can be defined as a palette for mixing and creating colors. "Windows" can also be used to display more than one illustration at a time, allowing the user to copy from existing illustrations or to lay out a multipage diagram. Any entity represented on the screen, either in the drawing space or in the template area, can be addressed by name or by pointing, including lines, figures, background, textures, colors, blank space, any "region" defined by the user, and text. The user may also address any group of entities or regions by drawing around them with a pointing device.

Any changes the user makes to an illustration, whether by copying, creating, coloring, filling in, or drawing, are immediately displayed. She can easily erase any part of the illustration, an entire figure or any part of it, or "back up" over a line at any time during the creation process. Because of possible distortion and inaccuracies of images on terminal screens, distances between any entities in an illustration may be specified in inches, centimeters, picas, and points, as well as simply by pointing to the screen. Upon request, the system will report the exact distance, according to any measurement, between any two points in the illustration. The user can display a grid of addressable points, according to any of the above measurements, over any part of the screen. As she works, the illustrator can "zoom in" to any portion of the screen for a closer look at detailed or complex areas. The additional capability to expand or reduce any entities or area of the screen by specifying dimentions or by pointing is is

especially useful for "blowing up" or "cropping" a portion of an existing illustration to create a new one.

The filter capability allows the user to selectively view, address, or produce a filtered print. Filtering can be by color (for example, show only red entities), entities (don't show background), or any combination of the two (show only blue triangles). This enables the user to make a print of a multicolor drawing in one color, view a flow chart without connecting lines, or change all sienna figures in an illustration to burnt umber.

Any illustration, whether or not it has been completed, can be easily stored and retrieved for printing or future work sessions. To provide for the input of illustrations or graphics that were created offline, the system can scan a hard-copy image and create a corresponding image on the screen that can be modified, printed, included in a document, or stored for future reference. The user can also retrieve graphics from other online systems. Additional capabilities provide automatic generation of graphs and bar charts from standard plotting languages and numerical data, including output from standard software systems.

Bibliographic Aids

Creating bibliographic and reference materials for documents is a process that especially lends itself to computer aids. Compiling the information, record keeping, and formatting are repetitious and tedious, and revision is particularly subject to error. This section describes how the ideal system will help make the contents and bibliographic information in documents easily accessible to the reader.

The Table of Contents

The system will generate tables of contents automatically. The user will be able to specify which headings should be included according to the logical structure of the document. For example, the user may want to specify a simple table of contents that would include only chapter headings, or one that includes sections and subsections within each chapter. Any text entity may be marked as a heading to be included in the table of contents. The user may also specify page numbers or numbers identifying the heading's position in the hierarchic structure of the document.

Lists of Figures, Photos, or Changed Pages

The system will generate lists of figures, photographs, illustrations, tables, or changed pages automatically. The user may specify how they should be labeled (for example, Figure 1 or Illustration 1), and whether or not corresponding page numbers or numbers identifying the heading's position in the hierarchic structure of the document should be included. Additionally, the user may mark any entity to be included in a list.

Indices

The user will have a choice of two methods for generating indices. One method will allow the user at any time to designate words and phrases in a document to be compiled into a key word table that may be associated with the document or that may be used with any document. When the user is ready to compile an index, the system will create an index, listing the terms included in the table with the page numbers on which they appear in the document.

The user can also specify that the system automatically compile an index for all terms in a document, excluding only those words contained in an exception list. The system will provide a standard exception list, which the user can add to or modify.

Bibliography

Two formatting aids are available to assist the user in creating a bibliography. One method allows the user simply to type in all relevant information, separating each field by a single unique character. The system will use this information to create a bibliography in one of several standard for-

mats. With the other method, the system will ask questions about the bibliographic information. For either bibliographic aid, the user can specify which fields should be included and how the citation should be formatted. A "ditto" facility that repeats the contents of the previous corresponding field will reduce repetitive typing.

When a list of bibliographic citations has been compiled, the user may request that it be sorted either alphabetically or by date.

References

To cite a reference in the body of a document, the user will issue a "Reference Citation" command. This will uniquely mark the place in the document where the citation is to appear, and place the required information for the citation (for example, author's initials and last name, date of publication, and page number) in an "invisible" data base. If the user wishes, this information may also be displayed online in the document at the appropriate location.

In citing a reference, the user has the option of including only enough information to distinguish it from other references, or all the bibliographic information that will go in the references section(s) of the document may be typed in immediately. Regardless of when the user chooses to complete the information for the references section(s), the system will provide two aids in this process. In the first, the system will search a previously compiled bibliography for the pertinent information. Or it will prompt the user for the required bibliographic information for each reference in cases where no previously created bibliography exists.

At any time, the user may request that the document be processed to show all citations and to create the reference section(s). The user will specify how the reference sections should be divided according to hierarchical structure, that is, should there be a list following each chapter or section or one list at the end of the document. The mark in the document or the displayed citation information will be replaced with a number or any other form of reference citation the user chooses. The system will sort the reference section(s) sequentially according to the order in which the citations appear in file or according to any other order specified by the user. The reference list will be created in one of several formats.

A unique number from an online catalog can be used to provide citation information as well as reference identification. Using the catalog number, the system will automatically fill in the appropriate information for the references section.

Glossary

At any time during the creation of a document, the user can insert words into a "glossary table," an invisible data base. The system will create an alphabetical list of all the terms included in the table, and the user can insert the list at any point in the document.

Footnotes

The user will simply type in footnotes, indicated by a special marker, following the text they reference. The system will lay out the document to accommodate the footnotes and number and compose them according to user specifications.

Document Design Tools

The ideal publishing system allows the user to create a layout design on a high-resolution display terminal or alphanumeric display, apply that design to any text, easily proof and change formatted pages, and automatically send a formatted document to a hard-copy printer or phototypesetter. It interfaces smoothly with the editing and graphics systems, described above, including capabilities for handling tabular material, footnotes, and other special features.

An important goal of document design tools should be to bridge the gap between traditional typographical processes and com-

puter tools to aid those processes. This is accomplished in two ways. First, the user interface is based on the vocabulary and concepts common in traditional book design and typesetting. Second, tools are unobtrusive, comfortable, and easy to use, so that the user can concentrate on aesthetic decisions without being distracted or hampered by technique. While some typographical expertise may be desirable for anyone using the system for design, the tools themselves may be used without extensive training.

The following description outlines the capabilities provided by a computer-based publishing system and, in some cases, makes suggestions for the best way to handle various phases of document design and layout. This description is followed by a list of all the formatting capabilities and typesetting elements the system encompasses.

Production Functions

We have organized the document formatting process into four functions. The first is the initial page and document design. Its product is a "comprehensive," an accurate layout showing type and illustrations as the designer envisions them for a page or entire document (Craig, 1971). Another function of the formatting process, which the designer may call on at any time, is copyfitting. The publishing system tells the user how much area will be required for any given piece of text, with specified type size and spacing.

After a page or an entire document has been designed, the format must be applied to the appropriate text. We call this process page makeup, and include in it all of the steps that must take place to make a file ready for hard copy printing or photocomposition, the last phase of the formatting process.

The ideal publishing system consists of a basic set of commands that insert printing instructions into a document. These commands may be used in two modes: Design and Page Makeup. Design mode is used to create an initial layout design, which will later be applied to a document. When in Design mode, printing instructions are assembled in a location specified by the designer; this set of instructions may be a newly created computer file or possibly a modification of a design contained in an already existing file. Page Makeup mode is used after the layout design has been applied to a particular document, to modify and adjust the design to fit that document. When in Page Makeup mode, printing instructions are associated with the text loaded for page makeup, in the appropriate places.

There are a few system capabilities that apply to all phases of the publishing process. The user interface for the system consists of an extensive command vocabulary that allows the user to create formats by telling the system the kind of printing instruction to apply to a document, the kind of output, the way the document is to be viewed, and so forth. For any commands that might take more than a few seconds to execute, such as those that apply a format to text, the user can request background processing. In addition, the user can turn off immediately anything he or she can turn on--processes as well as printing instructions.

The system handles any measurement in inches, centimeters, picas, and points, as well as user-defined measurements. (The user can also, of course, specify and adjust distances by pointing to places on the screen, rather than giving a measurement.) At any time the user can ask the computer to state the distance between specified page elements, in any of the above measurements. For example, the system will respond with the appropriate information when a user queries it for the distance, measured in points and inches, between the header and the body of the text, for a particular design. All calculations required in the page design and makeup process, such as intercharacter and interline spacing, are made automatically by the system, unless the user wants to do this manually.

Initial Design. Ideally, the first phase of format design takes place on a high-resolution, full-page display with graphics capabilities. The user first delineates a page, which is marked with boundaries on the screen, and then defines the layout by naming page elements, such as headers, footers, or margins; by specifying text strings and pointing to (or specifying numerically) where they should go on the page; or by pointing to type or page elements already in the layout and moving them around or changing them. The user can specify any page element by name, address, or pointing, and can refer to any location on the screen by address or pointing. He or she can also name printing instructions that do not necessarily show up on the page (such as paginate before every chapter).

When rearranging elements on a page, the user has the choice of having the system either adjust other page elements to accommodate the change or adjust white space only. If there is to be an adjustment, the user can specify which elements should be affected, and how much, or allow a default adjustment. For example, to move the footer up on the page, the user can either specify that the depth of the body be shortened, or else keep the body depth constant and decrease the white space between the body and footer.

The entire page design can be done with or without text. At any time the user can apply a format to text, specifying fonts and interword, interline, or intercharacter spacing, or allowing the system default for any of these if they have not already been included in the page design.

To put text in the page design, the user does not have to apply the design to an already existing file, nor does the text have to be designated as some page element. The user can insert a string of text anywhere on the page, without calling it a header, footer, and so forth, and move it around as she wishes. This is useful, for example, in designing highly illustrated material such as mechanical instruction manuals, which may not be made up of standard page elements. The user will also have the option of having default dummy type inserted anywhere in the page design.

To aid the designer in making the exact measurements necessary for page design, a grid may be specified for a full page or limited area. The grid can be defined in any of the measurements the system handles, as described above. It can be suppressed or brought back at any time. The user may bug or address any point on the grid.

The ideal publishing system recognizes an entity called a "design block." This is any arbitrary area the user defines on the page. It may be labeled and referred to by that label. A design block is delineated by line boundaries, but may be filled in with text at any time; when bugged or addressed, the boundaries defining it are highlighted. When a user wants to put some text in a previously specified design block, and the text does not fit properly in the font size and spacing specified, the system will state how many characters are in excess, and suggest a more appropriate character size and/or spacing.

The system also recognizes "white space" as an element to be manipulated, that is, an area of white space can be addressed and changed. To change the dimensions of the white space, the user can specify that some page elements or other areas of white space be adjusted. For example, in specifying that the white space between the left edge of the paper and the left margin be enlarged, the user can ask that the space on the right of the text be made smaller to allow the same line length in the text, or that the line length be shortened and the white space on the right of the text remain the same.

Formatting may also be done with the aid of an interrogation facility. Two kinds of interrogation are available for the page designer. The first allows the user to format a document without a high resolution display or without knowing how to use the individual design commands. The system

asks the user for all the dimensions it needs to create the page that has been requested. Those dimensions may be specified in numbers or by pointing to distances on the screen (if used with a high-resolution display).

Also available is a formatting "checklist" to remind the designer of any necessary printing instructions he or she might have forgotten to include in the design. This is particularly helpful for instructions that may not be required for each page, such as ensuring that each new chapter begins on a right-hand page.

The system provides simple storage and retrieval of page designs. Each design may be identified with a name, stored, recalled by that name for application to text or further revision, and stored again for future use.

Two helpful features are included for special page formatting. The user can define a center or edge to justify to while laying out the page. The user can also lay out and display more than one page at a time. Since this will mean presenting pages to scale, the system will adjust the proportions automatically. This feature is necessary, for example, to design brochures, where it is essential for the designer to see how pages look next to each other. The designer can design each page individually, with true (or enlarged) proportions, then place both pages on the screen, at a scaled-down size, to see how they look together.

The system can also easily distinguish pieces of text and layout for subsequent color separation. (This can be done with the "white space" concept.)

Copyfitting. Whenever the user requests it, the system will provide a page or line count, or the vertical or horizontal length for any piece of text. The user can either specify a pre-defined format to be applied to the text, or the system will interrogate the user for pertinent format specifications (for example, size and type face, line length, and maximum depth for pages). The user can get a rough estimate based on width tables for proportionally spaced type, or an exact count by actually applying a format to a document or part of a document. The system will also calculate type size and spacing when the user specifies a piece of text and a typeface, and defines an area into which to fit it.

Page Makeup. When the user is ready to apply a page design to a document or part of a document, the system will interrogate for any additional information necessary to apply the design to the text. Further printing instructions may be needed, or the format that is being applied to the document may require that the user fill in information for special pages. For example, the format might include a title page, so the system would interrogate for title, author, date, and so on. The process of applying the format to the text can take place in the background. More than one document can be processed at once, with the same or different formats. Each page may then be checked for special formatting problems.

Once a document has been formatted, individual pages or the whole document may be easily "hand altered" by individual commands in Page Makeup mode. For example, the user may wish to italicize particular parts of the text or rearrange page breaks. The user can specify instructions either by issuing commands and giving text arguments or by moving things on the high-resolution display screen. The user can address by pages as well as by logical structure and may then reset a line, part of a page or a whole page, a chapter or any other part of a document, the whole document, or a series of documents.

The user display at any time the formatting instructions specified for a particular format or document. Feedback about the format will be available in the form of prose description, as well as by displaying the format itself.

The system can produce two kinds of page proofs, depending on the available printer. If a line printer is used, proofs may be pro-

duced in monospace on wide, continuous paper. Although this will not give a very good representation of what the final photocomposed page will look like, it will show line and page breaks. A better approximation of photocomposed text can be provided on a raster printer or by scanning and copying a high-resolution display. This approximation will show the proper proportions and typefaces, although the quality of the type will be inferior to that of a photocomposer.

Photocomposition. Once the text is formatted and proofed, the user can send it to any quality photocomposition machine on the market. With the ideal system, the photocomposer must be able to handle anything that manual typesetting can. A list of these elements is given below.

Typesetting Capabilities and Type Elements

In this section we provide two lists. In the first we include all the typesetting capabilities for spacing and placement on the page. The second specifies the actual type elements or characters the system can handle.

Typesetting

Justification (hanging, random, runaround, centered, staggered, ragged, and flush); with ragged justification, the distance the shortest line should fall from the right or left margin can be specified. Adjustment can be done with intercharacter spacing.

Hyphenation, interactive or batch; user can specify 2 or 3 character hyphenation.

Indenting, by inches, picas, points, centimeters, ens, and ems at any point in a document.

Word spacing.

Line spacing.

Horizontal kerning. Both general letter spacing (escapement) and aesthetic kerning.

Columnation.

Running heads and footers.

Line and page widows, and single lines at the bottom of a page, are handled automatically.

Pagination can be forced at any point or by logical or organizational structure (for example, by chapter or section).

Font may be changed at any time.

Space for illustrations and captions are handled automatically. User can specify the size of an existing illustration, and if necessary, the system will determine the correct proportions for the illustration to fit it into the area specified by the user.

Automatic mirror image page design for two-sided printing.

Automatic numbering.

Footnotes are numbered and space for them is adjusted automatically.

Equations.

Glosses.

Can print sideways on a page.

Type Elements

Full range of type faces, sizes, and variations, including small caps and ligatures.

Special characters including the Greek alphabet and standard mathematical symbols.

Underlining and overlining.

Initial characters.

Ruling (lines, dots, dashes, and so on.).

Math characters.

Superscripts and subscripts.

Bullets.

Decorative borders.

Logos.

Diacritical marks.

Communication Facilities

The ideal publishing system provides tools to support the communication needs of a document's collaborators. We have not devoted a great deal of design attention to this area, which is essential to the publications process. The development of communications systems has had a history separate from that of other publication tools. Many sophisticated tools are commercially available and careful conceptual designs and descriptions are widely accessible (Engelbart, 1970; Katzman, 1973; Panko, 1977; Turoff, 1977; Vallee, 1976).

Tools are available for simultaneous interaction on tasks, for terminal linking over communication networks, for group and sequential delivery of messages, for the establishment of a record of work and dialog associated with a particular project, and for the online delivery of completed documents. Communication tools will be used both by human collaborators and by automated systems such as the Agent to keep everyone associated with a a project aware of its current state.

When geographically separated people want to work together on a document simultaneously, they will be able to establish multimedia communication channels. They will speak to each other using speaker phones at their work stations. Alphanumeric collaboration will occur through linked computer jobs. Each worker will be able to see on a display the same changing material as his collaborator and each will be able to make modifications and additions. Other computer-based teleconferencing systems will extend these features to larger groups for use in meetings.

A message facility will permit either the full text of short memos or citations to longer drafts and documents to be sent to individuals and groups. Sequential delivery will send material to members of approval lists, in the appropriate order for sign-off. All computer-based dialog may be recorded and cataloged for later retrieval and study.

Automatic Process Control: The Agent

To coordinate the entire production cycle, from inception to final distribution and storage, and to help ensure the timely progression of each document from one stage to the next, the model system provides a controlling mechanism that we call the "Agent" (see Figure 2).

The Agent is a tool for assisting in the production and supervision tasks and has no means of imposing a decision on any person. Depending on how it is used, the Agent can assume varying degrees of responsibility and control. Although the efficient use of any tool results in a better final product, the control exercised by the Agent relies on the cooperation of the participants and their willingness to be assisted and advised by it.

The purpose of the Agent is to coordinate a single document production cycle and to make available information on all the documents created within an organization. To do this, the Agent performs three basic functions. It maintains a large document production data base containing all the information relevant to each document being produced and keeps track of the data bases created for previous documents. It collects all the data necessary to produce, distribute, and refer to the document, and generates messages, correspondence, or reports from this data to track the production process, meet deadlines, and so forth. Finally, the Agent controls access to all of the online material related to a document, preventing unauthorized alteration of files and ensuring that work takes place on the most current files.

Below is a brief description of the three functions performed by the Agent. This is followed by a scenario tracing the role of the Agent in a typical production cycle.

Data Base Maintenance

The Agent creates the document production data base, sorts input into the proper categories, updates information, and performs limited analysis of the data necessary for Agent output. The data base is available to other tools, such as research tools and financial management tools, for analysis beyond that required by the Agent to accomplish its purpose.

The data base generally contains three categories of entries: coordinating and managerial information, cataloging information, and writing aids. Some entries fall into more than one category. Because the kinds of information required will vary among organizations and individual production cycles, the data base can be modified to fit the needs of a production environment or particular production cycle. A description of the kinds of information the data base is designed to handle is provided here.

Coordinating and Managerial Information. Coordinating information includes everything the Agent must know to assist in meeting and adjusting schedules, tracking document parts, and using resources efficiently. The Agent also supplies managerial information to people such as the managers of publication groups or organizational managers who are responsible for the existence, completeness, and timeliness of various documents. Managers can easily question the Agent on the status of documents and resources, including the state of completion, review, and expenditures for all documents in their jurisdiction or for one particular document. Below is a typical list of coordinating and managerial information the Agent requires:

1. *Document Identification.* This includes a unique identification number (which may be the same as its catalog number) assigned by the Agent, the title of the document, and any other information used in the organization to identify the document.

2. *Current Personnel.* Typically, the personnel the Agent needs to know about include a supervisor or document production manager (the highest authority responsible for the existence of a document), a production coordinator, authors, editors, reviewers, clerks, layout designers, and illustrators.

3. *Schedules and Task Assignments.* When a new document production cycle is initiated, the Agent needs a rough schedule that sets a deadline for the first action on the document. Eventually a full schedule is required, including personnel assignments and deadlines for all tasks--writing, editing, layout design, illustrations, and so on. The Agent is responsible for keeping the schedule and task assignments updated.

4. *Resource Allocation.* Resource allocation, measured in number of person-hours required and dollars, are recorded by the Agent and expenditures kept up to date automatically.

5. *Outline and Tracking of Document Parts.* A detailed outline of the document is maintained by the Agent, along with the location and completion status of all of the parts of the document, including illustrations, format information, and material stored at offline workstations. The Agent also lists and enforces reading, writing, and copying access to each document part. In the special case of functional documents (see "Editing Tools"), the Agent must know the update status of each page. If an update page is in development but not yet distributed, the Agent must note this information. For control purposes, an update page in development will be treated in many ways like a separate document.

6. *Approval Chain and Status.* A list of everyone who must approve the document or portions of the document production and the order in which approval must take place is maintained by the Agent. As the document works its way through the approval process, each sign-off is recorded.

7. *Distribution List and Status.* A list of everyone who should receive the document and the date when the document was sent to the recipient is kept in the data base.

Production coordination, more than other tasks, is organization dependent and the relative importance of coordination issues varies widely. For example, when deadlines have to be met, the schedule may be of extreme importance; in other cases resource allocation (time and money spent on the production) may be of the highest priority. The Agent must be familiar with the priorities to provide reasonable coordination.

Cataloging Information. Catalog entries encompass all the information that will be needed to classify and access the document for reference purposes after it is completed. Typical entries in this category include title and subject classification, catalog number, key words and index words, abstract, distribution lists, security classification, a coordinator responsible for the document once it is cataloged, and access rights to the content (both at production time and after distribution). Many documents are updates of, or complements to, previously published documents, while others make previous documents obsolete. This information must also be recorded. Some catalog information will overlap that in other categories; for example, the distribution list is also required for coordination and as a writing aid.

Cataloging information may not only be important for future reference; it may affect the current production cycle or require the Agent to initiate other actions. For example, the subject, key words, or authors may determine to whom the document will be distributed. When a document is an update or a complement to a previous document, the Agent will ensure that distribution includes recipients of the previous documents, and that copies of the previous document are also available for distribution.

Writing Aids

Writing aids contain vital information for writers and other workers participating in the creation of the document. Included is information an author needs to know before beginning to write, as well as resources for layout design.

1. *Information Sources.* The location of notes, articles, previous documents, contact reports, and correspondence relevant to the current document, are maintained in the data base. Lists of people who might contribute information are also included.

2. *Initiating Documents.* The location of any document, such as a proposal, contract, RFP, or correspondence which explains why the document is necessary or outlines what is expected in it, is recorded.

3. *Document Specifications and Style Guidelines.* Document specifications, such as length or frequency of publication (for example, a monthly report), are kept in the data base. Also specified are any standard writing or punctuation guidelines (imposed either by the organization publishing the document or by the source requesting it) to which writers are expected to conform.

4. *Layout Specifications.* Specifications for the layout of the document, for example, if it is to conform to the printing specifications for a professional journal, are included.

5. *Distribution.* Distribution should also be included here, because it is relevant to the writers. The "audience" they are writing for must be pinpointed.

6. *Outline.* An outline for the whole document will be continually accessed and revised by the writers.

Data Gathering and Dissemination

To assist in coordinating a smooth production cycle and to maintain the data base, the Agent must collect data (input) from

various sources and produce various kinds of output. Generally, the Agent can accept any relevant information at any time and analyze and use it when necessary. However, some of the data must be collected at specific points in the production cycle, since it may determine the next action to be taken (for example, approval of a draft may be required before it moves to the next step). Likewise, some output must be generated at specific points of the production cycle (usually in the form of a message or report), while responses to queries may occur at any time.

Some kinds of input, such as schedules, access rights, and task assignments, can come from only one source--the production coordinator or an authorized representative. Other input must come from those carrying out tasks or approving the document at its various stages.

The Agent will request the information it needs at each step. It is designed with a built-in schedule for requesting information tailored to each organization; the production coordinator may modify this schedule at any time. For example, when the production coordinator initiates a new data base for a new document, the Agent will automatically assign an identificaton number and ask for the title of the document, the initiating sources, a list of the staff, the publishing deadline, and the time the next action on the document should take place. If the coordinator chooses to ignore any of these items, either the Agent will automatically request them at a later date or the coordinator may specify the time when the Agent should request them. Additionally, the coordinator may ask the Agent to prompt for any other information at any time.

When the Agent receives a schedule and task assignments, it uses this as its basis for further information requests. It will also notify personnel of their tasks, due dates, approaching deadlines, and so on, according to the schedule.

The coordinator is not expected to input all information. Status reports, including estimates of percent of completion and hours worked, are input by the staff. They must also report the location of parts of the document and document design specifications, and provide new estimates of the time required to complete a task when it is clear a deadline will not be met.

Output is provided in the form of reports, reminders, messages, and work-in-progress drafts of the document. The production coordinator may request any kind of output, in any format. Some typical reports that may be requested at any time (assuming the data base has received the necessary input) include: work-in-progress reports, a compilation of hours worked per task and estimates of degree of completion for unfinished tasks; status of the document reports, a complete list of the locations of all material pertinent to the document; and financial status reports, including how much has been spent, how much is left, who has been spending the money, and what it has been spent on.

Reminders to staff members about tasks for which they are responsible are produced automatically by the Agent. The frequency of these reminders may be adjusted by the production coordinator. This aspect of the Agent is carefully designed to serve as a helpful aid to personnel, not to be an annoying nag.

Status messages between personnel are handled automatically by the Agent. For example, when a reviewer has read and approved a section of the document, a message to this effect is automatically sent to the author of that section and to the next person who must deal with that section.

At any time, the user may request that the Agent print out a current draft of the document. It will appear as an outline that is filled out with as much as has been written.

Access Control and File Integrity

Access control of files containing material for the document, parts of the document, and layout design is necessary for three

reasons. It is difficult to coordinate document production when several people are involved and several files required; there is always the danger that an out-of-date draft will be written on, edited, or reviewed. Controls are necessary to make only the current file available for writing and provide warnings on outdated versions for reading and copying. It is also necessary to protect file integrity against accidental manipulations by those not familiar with it and allow privacy for those who prefer not to have their material read or written on by others. In addition, some environments require file security for classified work.

Reading, writing, and copying access can all be controlled. Default protections are provided by the Agent, which may be modified by the production coordinator and staff (except in special cases, such as classified work). The production coordinator can always override any protection set on any file containing material for the document.

To ensure that the current version of a file is the one available for work, the Agent provides two automatic aids. When a new file is created, the Agent queries the creator about where the information it will contain fits in the document outline or task assignment. If a file has already been created for that part of the outline or task, the Agent asks if the new file is a replacement for the old or additional to it. If no file is there, the new file is automatically recorded as the working file for that task or section of the document. Every time a file is updated, the Agent makes it the current file, locking the older version against further writing, and warning those who access it for reading and copying that there is a more recent version. Of course, this safeguard may be overcome whenever necessary.

To further protect against confusion among versions of files, the Agent maintains a history of the work done on each file. This includes a record of all cross-file copying or moving (that is, the date when some part of the file was copied or moved to another file, or into that file from another file, the source of copied or moved material, and the user). The time and user for each update or renaming of the file are also recorded.

The Agent also automatically performs automatic batch back-up, archiving, and copying to other mainframes for all files. The intervals at which this is done may be set by the project coordinator and may vary from file to file.

Access to the data base is limited to authorized personnel; this may include the production coordinator and, if necessary, a programmer who helps the coordinator modify the data base. No one else may tamper with its contents or structure except through the normal channels of input.

The Agent in Action

The following scenario describes the role of the Agent throughout a typical document production cycle. We have chosen the production cycle of a user manual for a computer system as our example.

A computer system has been developed which requires a user manual. The supervisor of the software group assigns its chief technical writer the job of production coordinator. The production coordinator's job is to see that the manual is written, published, distributed, and cataloged for future reference. She relies on the Agent to help her manage this task.

The coordinator initiates a documentation production data base for the user manual. The Agent assigns an identification number to the user manual and asks for its title, a publishing deadline, a list of all the staff who will be working on it, and the initiating sources (for example, the memo from the supervisor of the software group that states the requirements for the manual). The production coordinator provides the title, deadline, and a partial list of staff. Since the coordinator does not yet know what staff members are assigned to the project, she tells the Agent to request a list of staff in three days. The coordinator also

cites an online memo from her supervisor that requests the documentation and generally outlines what it should contain.

The Agent asks what actions will be taken next and when it should prompt for them. The production coordinator tells the Agent to prompt her for a full schedule and task assignments in one week and prompt the prospective authors to begin gathering information for the document in two weeks.

During the next three weeks, the Agent carries out the tasks it has been assigned and receives more input. When the authors have gathered information in preparation for writing, they record the location of their notes, relevant correspondence, and so on, in the data base. The Agent produces a complete listing of these sources upon request. A week later the Agent prompts the production coordinator, who gives the Agent a full schedule for the document production and individual task assignments.

Once the Agent has received a schedule and task assignments, it can act independently of the coordinator. It begins to prompt staff members for all the data it needs--further coordination information, such as resource allocations, cataloging information, and writing aids.

The Agent plays an active role in managing the project. For example, several days after it has received the schedule, it reminds the chief author that an outline is due in three days. Realizing that this deadline cannot be met, the author responds that he will require at least two extra days. The Agent sends a message to this effect to the production coordinator, requesting approval for an alteration in the schedule. The production coordinator discusses the slippage with appropriate staff, approves the change, and tells the Agent to adjust the entire writing schedule accordingly, slipping all writing deadlines back two days.

The Agent also helps staff members to communicate with one another. About halfway through the project, the graphic artist responsible for layout design of the user manual notifies the Agent that three preliminary designs are ready to show relevant staff members. The Agent consults the approval list for layout design, checks the schedule for final design approval, and sends a message to those staff members who are involved in the approval process that three designs are ready, that a meeting between them within two days would give the layout designer time to make the necessary changes and still meet the deadline, and that the designs are available for inspection at the locations listed. The message also asks for convenient meeting times. When the Agent receives this input, it schedules a time that will be most convenient to most staff and notifies them accordingly.

Most of the information needed by the writers has been examined, the style guidelines are understood, and the outline is completed. The user manual will be broken into five chapters, each chapter written by a different writer and having its own file. The Agent is responsible for tracking the files and ensuring their integrity. The writer of Chapter 4 creates a file called "chap4". The Agent asks the writer how the information in that file corresponds to the outline. The author responds that the file will have all the information for outline item 4. The Agent incorporates this into the data base, creating a record of the location of all work in progress as it relates to the outline. It also asks the writer what kind of file protection he would like on the file, noting that the default protection for files on this project is that only the creator of the file may write on it, but anyone else involved in the project may read it or copy from it. The writer assents to this protection. At the end of each work session after that, when the author updates his file, the Agent records the new version in the outline, and locks the previous version against further writing.

When the outline is revised by the staff a few days later, Chapter 4 is moved up to become Chapter 2. The author decides to rename his file to reflect this change. The Agent records the new name in the outline automatically, and sends a message to this effect to the other writers on the project.

About three-fourths of the way through the writing process, the supervisor of the project wants a full status report. The production coordinator notifies the Agent that by 9 a.m. the next day a resources status report, an updated schedule comparing slippage against original deadlines, and a draft of the current document will be needed. The Agent prepares the report, schedule, and draft that night.

The supervisor observes the schedule slippage and seeks information to decide what to do. The supervisor asks the Agent for the time commitment of all writers in the publications group and a listing of the production status of all active projects that are partially written with page allocations.

When the supervisor decides that meeting the original deadline is more important than the expense of the project, and that a writer is available, the production coordinator supplies the Agent with a new schedule, adds a writer to the staff, and makes new staff assignments. The supervisor also tells the Agent to notify staff members of the changes and remind them of their deadlines earlier and more frequently, except for Fred Frood, who is already resentful of the Agent's prompting and has been meeting deadlines consistently.

The Agent coordinates the review and editing process that begins as each writer completes sections of his chapter. Several authors ask the Agent to request informal reviews by fellow authors as they go along. The Agent makes the request for the original writer, and notifies him when the review is complete. Occasionally the production coordinator will ask to review sections; the Agent also handles this transaction. Formal editing takes place as each chapter is completed. Some drafts require further revision by the writers, while others are ready for approval. The Agent notifies the writers, editors, and production coordinator of the status of each chapter as it progresses through the editing.

While page makeup is taking place, the production coordinator reviews a final draft of the document. She then asks the Agent to inform everyone who will be approving the document when they will receive copies and how long they have for review. The Agent tracks the document as it goes through review, recording the approval at each step. Unfortunately, the president of the company decides he does not like the typeface chosen for the body of the manual. The Agent informs the production coordinator and layout designer of this fact. A new typeface is chosen, approval granted by the president, and a new version of the manual with the new typeface is made up. The president is pleased; the Agent congratulates the production staff on a job well done.

The Agent examines the distribution list to get an estimate of how many copies of the manual should be printed. It notes that a similar document on an earlier version of the system was distributed to 1,000 users, and that at least an additional 1,000 are now using the new system. The production coordinator requests that the Agent scan a general distribution list based on key words for other potential recipients. In addition, in-house distribution, copies for marketing, and a default "additional copies" number are all calculated, and a printing cost estimate provided for the production coordinator. The user manual is sent to press. Meanwhile, the Agent is having mailing labels and letters of transmittal prepared, and has prompted the production coordinator for some cataloging information that has not yet been recorded--key words, subject classifications, and the name of the person responsible for the document after it is cataloged.

A publication announcement is automatically distributed to members of the staff. Included is an abstract of the manual and catalog information that enables any interested person to print out a copy of the online manual. The Agent keeps track of the actual distribution process. When a client complains that he has not yet received his copies of the manual, the distribution clerk can ask the Agent whether copies have been sent, when they were sent, and who sent them. If there has been an

oversight, the Agent will see that the proper action is taken, and have a letter of apology sent to the client.

The job of the Agent does not end when the document has been distributed. It catalogs the document, and maintains appropriate information that will make it easily accessible in the future. Furthermore, when there are corrections to be made to the manual reflecting a change in the system it describes, the Agent will initiate a new production cycle, and see that the correction pages are distributed and cataloged properly. An Agent's work is never done.

CONCLUSION: THE NEED FOR AN INTEGRATED SYSTEM

Appendix II summarizes the principal document production tasks and lists particular features of our ideal system relevant to each. Within each task area, we have ranked the features by their priority for inclusion in the document production system. We looked at the needs and current practices of publications workers surveyed in preparing the Phase One report, Document Production and Control Systems, for guidance in establishing the relative usefulness of specific features of the ideal system. Features useful in specialized applications are noted and ranked separately. Costs of implementation are not discussed here; such estimates will appear in the Phase Three report. Additional system features dealing with reliability and response, user control and system feedback, the work station environment, and the file system are relevant to all tasks. We have listed and ranked them in Appendix II.

Rather than being composed of several isolated tools for each specialized task, the system features discussed in this report fit together into a coherent whole. There is much to be gained from such an approach.

Although functional roles may indeed be different, there are times when individuals may have to cover several roles. Thus an author may not only enter his or her own material, but also prepare the layout and begin the reproduction process. This interchangeability of roles is best accomplished through an integrated system with a similar user interface in each of its tools accessible from a single set of terminal equipment.

Conversely, in a large organization, many people may collaborate on single documents. These people may be distributed geographically and organizationally. For example, people from the Air Force and the Navy may have to collaborate on a document. People will require the material produced by others on the production team to perform their tasks; output fom one function serves as input for another.

In an integrated system, the flow of material is direct. Supporting communication fa-

cilities lead to timely receipt of material by others in the production team. The Agent performs additional support needed to control the production of the document. In an unintegrated system, material from one tool often must be converted for use on other tools. User interface languages may be vastly and confusingly different for each tool, further complicating the collaboration. The problem of learning difficult, unrelated command languages has reduced user acceptance of computer systems.

The development of a system as large and complex as that we propose is most readily and cost-effectively accomplished in an evolutionary manner. Almost all the most essential elements are already available in isolated systems or may be designed and implemented with minimal effort. Integrated under a general system design and interface framework, the available elements may adequately serve as the core of the ideal system. Meanwhile, development may continue in an upwardly compatible manner on more advanced features. Assuming a robust framework for the initial system, evolving additions will be easily introduced to the user community as they are created.

GLOSSARY

Batch processing. The user gives a task to the computer and is then free to do other work until the job is completed. Jobs are done one at a time on the basis of a waiting line. Users typically have only indirect contact with the computer, and in conventional systems the user may have to wait hours or even days for the completed job.

Bullet. Large dot used in documents for emphasis or as an ornament.

COM (Computer Output to Microfilm). This literally means making microfilm of computer data. However, the term COM is often loosely used to mean the process of making printed copy from a computer file.

Comprehensive. An accurate sample layout of a page showing type and illustrations in position.

Copyfitting. Determining the area required for a given amount of printed text (copy).

Crash. A computer system that has ceased to function due to hardware or software failure has "crashed."

CRT display (cathode-ray tube display). The computer presents text to the user on the screen of television-like devices. Images are plotted point by point on the face of the tube by directing a beam of electrons onto a luminescent screen. CRTs used for daily work are now mostly ordinary, black and white television tubes. More sophisticated CRTs have been produced for specific purposes.

Data base. A set of data or information on which operations and conclusions can be based.

Em. Traditionally the actual width of the letter "m" for each particular set of type, an em is now calculated as the square of the type body size. An em of 10-point type is 10 points by 10 points.

En. One-half the width of an em.

Feedback. The display of information to users by the computer to aid them in their

work. This information may serve as a prompt for the next action required of the user.

Files. In the context of a computer-based publication system, a file is a collection of online text and/or graphics that is treated as a unit.

Flush. Type set with no indents. This can be flush left, flush right, or both.

Font. All the characters and spacing for one size and style of type.

Hanging justification. Lines of type are aligned both on the left and right, but punctuation marks fall outside the right margin.

Hard copy. Typewritten or printed characters on paper as opposed to text displayed on a CRT screen.

Hardware. The mechanical, magnetic, electrical, and electronic devices or components of a computer.

Hot type. Type produced by casting in hot metal.

Initial character. The first letter of a chapter or paragraph that is set in display type for decoration or emphasis.

Interactive processing (online processing). As opposed to batch processing, tasks are carried on through a dialog betwen user and computer. The user types a command at a computer terminal, receives a rapid response, and then types another command.

Interrogate. Simple inquiry by the system for which a quick reply is expected from the user.

Kerning. In typesetting, controlling the space between individual letters, including the parts of the letters that are prolonged beyond the body.

Layout. A rough drawing representing the typographic elements (blocks of text and illustrations) in their proper positions.

Optical character recognition. To enter offline information into the computer, a computer device reads text from a printed (or occasionally handwritten) page.

Ligatures. Two or three characters combined into a single letter; in carefully designed type faces, this is frequently done with "ff" and "fi".

Light pen. A device shaped like a pen that is used to point at things displayed on a cathode-ray tube screen.

Page makeup. Process of arranging lines of type in position as specified by the layout.

Photocomposition. Typographic material produced photographically. Also known as "phototypesetting" and "cold type."

Pica. Typographic unit of measurement. There are 12 points to a pica and 6 picas to an inch.

Point. Smallest typographic unit of measurement. Actually .01384 inches or approximately 1/72 of an inch.

Ragged left. Type is set so that the lines are aligned on the right only.

Ragged right. Type is set so that the lines are aligned on the left only.

Random justification. Each line of text is aligned individually for aesthetic effect, including a possible mixture of centered lines, flush lines, ragged lines, and indented lines.

Runaround. Fitting type around an illustration or photograph.

Small caps. Roman uppercase alphabet in which the letters are the same height as the lowercase letters.

Software. The programs that control the operations of computers--as opposed to hardware.

Staggered justification. Even lines of text are aligned according to one set of margins and odd lines of text are aligned according to another set of margins.

Work station. A terminal or collection of terminals and associated furniture and equipment at which a person uses a computer system.

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Appendix I: SYSTEM SOURCES

In doing research for this and the previous report, we examined material from a large number of organizations. We have listed these organizations below as a source of information for anyone interested in learning about the field of word processing. Most of them are organizations that offer publications systems or sevices. In other cases, such as the American Chemical Society, they are the site or sponsor of significant development work.

Acts Computing Corporation
29200 Southfield Road
Southfield, MI 48076

AES Data Limited
570 McCaffrey Street
Montreal, Quebec H4T 1N1
Canada

Alphatext Incorporated
Hearst Building
5 Third Street
San Francisco, CA 94103

Alphatext Limited
233 Gilmour Street
Ottawa K2P OP1, Canada

Alphatype Corporation
7500 McCormick Blvd.
Skokie, IL 60076

American Chemical Society (ACS) Industries, Inc.
2701 Pellissir Place
Whittier, CA 90601

Note: Under National Science Foundation grants, the ACS has developed a sophisticated page formatter and a group of other aids used for their own journal production. They are not commercially available at this time.

Analysis and Programming Corporation (APC)
423 State Street
Beloit, WI 53511

ARCO Products
311 Stewart Avenue
Addison, IL 60101

Artec International Corporation
Charleston Business Park
2432 East Charleston Road
Mountain View, CA 94043

Autologic, Incorporated
9119 De Soto Ave.
Chatsworth, CA 91311

Automix Keyboards, Inc. (AKI)
4200 150th NE
Redmond, WA 98052

Avionic Products Engineering Corporation
Ford Road
Denville, NJ 07834

Bancroft Computer Systems
1200 North 18th Street
Monroe, LA 71201

Base, Inc.
437 Madison Ave.
New York, NY 10022

Bedford Computer Systems, Inc.
Three Preston Court
Bedford, MA 01730

Bell Telephone Labs, Inc.
600 Mountain Avenue
Murray Hill, NJ 07974

Bowne Time Sharing, Inc.
345 Hudson Street
New York, NY 10014

The Braegen Corporation
405 Tasman Drive
Sunnyvale, CA 94086

Bristol Information Systems, Inc.
P.O. Box 2133
56 North Main Street
Fall River, MA 02722

CBI Business Forms Company
3322 West Peterson Avenue
Chicago, IL 60659

Commercial Systems Consultants
3246 McKinley Drive
Santa Clara, CA 95118

Comptek Research, Inc.
445 Cayuga Road
Buffalo, NY 14225

Compugraphic
80 Industrial Way
Wilmington, MA 01887

Compuscan, Inc.
900 Huyler Street
Teterboro, NJ 07608

Computer Dynamics, Inc.
100 Hegenberger Road
Oakland, CA 94621

Computer Innovations
Suite 401
70 West Hubbard Street
Chicago, IL 60610

Computer Sharing Services, Inc.
2498 West Second Avenue
Denver, CO 80223

Context Corporation
4 Ray Avenue
Burlington, MA 01803

CPT Corporation
1001 S. 2nd Street
Hopkins, MN 55343

Curtis 100
1000 Curtis Drive
Smyrna, Georgia 30080

Daconics
(subsidiary of Xerox Corp.)
925 Thompson Place
Sunnyvale, CA 94086

Data General Corporation
Southboro, MA 01772

Datagraphix, Inc.
P.O. Box 82449
San Diego, CA 92138

Datapoint Corporation
l9725 Datapoint Drive
San Antonio, TX 782184

Data Technology Industries, Inc.
6611 Kenilworth Ave.
Riverdale, MD 20840

Data Tek Corporation
University City Science Center
3401 Market Street
Philadelphia, PA 19104

Data Terminals & Communication
1190 Dell Ave.
Campbell, CA 95008

Dennison Office Equipment
300 Howard Street
Framingham, MA 01701

A.B. Dick Company
5700 West Touhy Ave.
Chicago, IL 60648

Digital Equipment Corporation
Maynard, MA 01754

Display Text Corporation
1420 "N" Street, N.W.
Suite CCT-2
Washington, DC 20005

Eastman Kodak Company
Business Systems Markets Division
Rochester, NY 14650

Edit Systems, Inc.
1353 Main Street
Ann Arbor, MI 48104

Edityper Systems Corporation
(subsidiary of Tycom)
26 Just Road
Fairfield, NJ 07006

First Data Corporation
400 Totten Pond Road
Waltham, MA 02154

Franklin Data Services Corp.
1 Franklin Square
Springfield, IL 62704

General Computer/Systems, Inc. (GC/S)
16600 Dooley Road
Addison, TX 75001

Genesis One Computer Corporation
300 East 44th Street
New York, NY 10017

Glaser Data Company
225 Forest Ave.
Palo Alto, CA 94301

Graphic Systems, Inc.
801 Second Ave.
New York, NY 10017

Hackett Corporation
2100 W. Fullerton Avenue
Chicago, IL 60647

Harris Corporation
1650 S. Amphlett Blvd., Suite 228
San Mateo, CA 94402

HDR Systems, Inc.
8404 Indian Hills Drive
Omaha, NE 68114

Hendrix
Grenier Industrial Park
645 Harvey Road
Manchester, NH 03103

Hewlett Packard
1501 Page Mill Road
Palo Alto, CA 94304

Honeywell Information Systems
200 Smith Street
Waltham, MA 02154

IBM Corporation
Data Processing Division
1133 Westchester Ave.
White Plains, NY 10604

IBM Corporation
Federal Systems Division
Old Orchard Road
Armonk, NY 10504

IBM Corporation
General Systems Division
5775 D Glenridge Dr. NE
Box 2150
Atlanta, GA 30301

IBM Corporation
Los Gatos Laboratory
6450 Guadalupe Mines Road
Los Gatos, CA

IBM Corporation
Office Products Division
Parsons Pond Drive
Franklin Lakes, NJ 07417

Information Control Systems, Inc.
P.O. Box 281
Ann Arbor, MI 48107

Information International, Inc.
5933 Slauson Avenue
Culver City, CA 90230

Intelligent Systems Corporation
4376 Ridge Gate Drive
Duluth, Georgia 30136

Jacquard Systems
2502 Broadway
Santa Monica, CA 90404

Lanier Business Products
1700 Chantilly Drive, NE
Atlanta, GA 30324

LCS Corporation
31 Elm Street
Springfield, MA 01103

Lexitron Corporation
9600 DeSoto Ave.
Chatsworth, CA 91311

Linolex Systems, Inc.
(subsidiary of 3M Company)
5 Esquire Road
North Billerica, MA 01862

Lockheed Missiles and Space Company
1111 Lockheed Way
Sunnyvale, CA

Note: Lockheed has developed Autotext, one of the most sophisticated document production systems running on half-duplex equipment. It is used internally in this Lockheed division, but is not now externally available.

Logical Machine Corporation
887-A Mitten Road
Burlingame, CA 94010

Logicon
21535 Hawthorne Blvd.
Torrance, CA 90503

Management Systems Corporation
125 North State Street
Salt Lake City, UT 84103

MCM Computers, Inc.
2125 Center Ave.
Fort Lee, NJ 07024

Megatek Corporation
1055 Shafter Street
San Diego, CA 92106

Mentel, Inc.
459 Hamilton Avenue
Palo Alto, CA 94302

Mergenthaler Linotype Company
29 Ryerson Street
Brooklyn, NY 11205

Micom Data Systems Ltd.
447 Saint Helen Street
Montreal, Quebec H2Y 2K9
Canada

Mycro-Tek, Inc.
216 North Washington
Wichita, KS 67201

National CSS, Inc.
542 Westport Avenue
Norwalk, CN 06851

NBI
5595 East Arapahoe Ave.
Boulder, CO 80303

Occidental Computer Systems, Inc.
10202 Riverside Drive
North Hollywood, CA 91602

Office Communications, Inc.
766 Palomar Ave.
Sunnyvale, CA 94086

Okidata Corporation
111 Gaither Drive
Moorestown, NJ 08057

Olivetti Corporation of America
500 Park Ave.
New York, NY 10022

Omnitext, Inc.
P.O. Box 2090
Ann Arbor, MI 48108

On-Line Business Systems, Inc.
115 Sansome St.
San Francisco, CA 94104

Optimum Systems, Inc.
2801 Northwestern Parkway
Santa Clara, CA 95051

Perkin-Elmer Data Systems
Route 10 and Emery Avenue
Randolph, NJ 07801

Phillips Business Systems
175 Froehlich Farm Blvd.
Woodbury, NY 11797

Proprietary Computer Systems, Inc.
16625 Saticoy Street
Van Nuys, CA 91405

QI Corporation
6 Duban Court
Farmingdale, NY 11735

Qualterm Terminals
2007 O'Toole Ave.
San Jose, CA 95131

The Rand Corporation
1700 Main Street
Santa Monica, CA 90406

Note: This is a site of development work, but not a commercial vendor.

Rapidata, Inc.
20 New Dutch Lane
Fairfield, NJ 07006

Raytheon
141 Spring Street
Lexington, MA 02173

Redactron Corporation
100 Parkway Drive South
Hauppauge, NY 11781

Rockwell International
2735 Curtiss Street
Downers Grove, IL 60515

Royal Typewriter
Division of Litton Industries
150 New Park Ave.
Hartford, CT 06106

Satellite Computing Corporation
3330 North Central Ave.
Phoenix, AZ 85012

Savin Business Machines Corporation
Columbus Ave.
Vallhalla, NY 10595

I.P. Sharp Associates Ltd.
Suite 1400
145 King Street West
Toronto, Ontario M5H 1J8
Canada

Sperry Univac
Office Machines Division
P.O. Box 1000
Blue Bell, PA 19422

System Development Corporation
2500 Colorado Avenue
Santa Monica, CA 90406

Systems Technology, Inc.
107 Sachem Street
New Haven, CT 06511

Tally Corporation
8301 South 180th Street
Kent, WA 98031

Telecommunications Industries, Inc.
7670 Old Springhouse Road
McLean, VA 22101

Trendata Corporation
610 Palomar Ave.
Sunnyvale, CA 94086

Tri-Star Computer Systems, Inc.
304 Harper Drive
Moorestown, NJ 08057

Tycom Systems Corporation
26 Just Road
Fairfield, NJ 07006

Ty-Data, Inc.
109 Northeastern Blvd.
Nashua, NH 03060

Tymshare, Inc.
10340 Bubb Road
Cupertino, CA 95014

University Computing Company
P.O. Box 6171
Dallas, TX 75222

Ventek Computer Systems, Inc.
31829 West La Tienda Drive
Westlake Village, CA 91361

Vydec, Inc.
130 Algonquin Parkway
Whippany, NJ 07981

Wang Laboratories
836 North Street
Tewksbury, MA 01871

Western Union Data Services
70 McKee Drive
Mahwah, New Jersey 07430

Westinghouse Electric Corporation
2040 Ardmore Blvd.
Pittsburgh, PA 15221

Wordplex Corp.
31829 W. La Tienda Drive
Westlake Village, CA 91361

World Information Systems Incorporated
17501 South Figueroa Street
Gardena, CA 90248

WP/RS Concepts Company
P.O. Box 79
3158 Production Drive
Fairfield, OH 45014

Wright Line
A division of Barry Wright Corp.
160 Gold Star Blvd.
Worcester, MA 01606

Xerox Corporation
1341 West Mockingbird Lane
Dallas, TX 75297

Xerox Palo Alto Research Center
3333 Coyote Hill Road
Palo Alto, CA

Xmark Corporation
1539 Superior Ave.
Costa Mesa, CA 92627

Appendix II: IMPLEMENTATION PRIORITIES

Information Gathering and Writing

High Priority

Links.

Type-in mode.

Medium Priority

Conversion and input of material from other systems, including data processing.

Low Priority

Key word filters.

Text entity filters (for example, show all footnotes).

Back links.

High Priority--Specialized Applications

Catalogs.

Commands for inputting tables.

Medium Priority--Specialized Applications

OCR device.

Editing

High Priority

Commands to type in, delete, replace, move, and copy text and type in, delete, replace, move, copy, combine, and divide text entities.

System will highlight text that is the object of commands.

Print filtered versions of documents.

Automatic spelling and punctuation correction.

Global substitutes.

Medium Priority

No computer boundaries for commands.

Portray formatted draft at any time.

Blue pencil editor.

High Priority--Specialized Applications

Commands for editing tables.

Text editing works on text in illustrations.

Illustration

High Priority--Specialized Applications

Templates for copying figure elements.

Illustrations easily integrated into documents.

Erasing.

Translation of graphics from other systems.

Medium Priority--Specialized Applications

Free-hand drawing.

Color, including mixing palette.

Full typography integrated into drawings.

Distances specified in points, centimenters, picas, inches or whatever user wishes.

Grid.

Zooming (changing the view).

Blowing up and cropping (changing the drawing's size).

Hard-copy illustration scanner.

Low Priority--Specialized Applications

Dynamic Flowcharting.

Texture.

Background.

Illustration filters.

Bibliographic Aids

High Priority

Automatic generation of tables of contents, lists of figures, changed pages, indicies, bibliographies, and glossaries.

High Priority--Specialized Applications

System will lay out footnotes.

System will format references.

Document Design and Layout

High Priority

System can automatically lay out complete documents.

System will interrogate for basic format requirements.

Copyfitting.

Low Priority

System will interrogate for esoteric format requirements.

High Priority--Specialized Applications

User can manipulate block of text or space via "design blocks".

User can specify any page element by name, address, or pointing.

User can specify any traditional typesetting capabilities or type elements.

Medium Priority--Specialized Applications

Separations for color printing provided by system.

Communication

High Priority

Message sending.

Medium Priority

Terminal linking.

Recorded dialog.

Low Priority

Teleconferencing.

Control: The Agent

High Priority

Interrogates for information to maintain a data base for project management.

Sends reminders to staff according to predefined deadlines.

Provides reports and information on an individual document production cycle.

Tracks various sections of documents in progress to provide most current draft.

Provides automatic backup and control in case of computer crashes.

Medium Priority

Provides reports and information on the total allocation of document production resources and scheduling for an entire organization.

Automatically distributes online documents.

Sequential delivery for approval.

Low Priority

Automatically catalogs completed documents.

High Priority--Specialized Applications

Controls access to files.

System Reliability and Response

High Priority

Central computer to accommodate operations over large files.

Capable of incorporating new technologies with integrated mini- and microprocessors.

File system backup. Automatic duplication.

Highly interactive.

Feedback supporting typing speeds up to 100 words per minute.

Mean response time for simple operations of less than 2 seconds with standard deviation of not more than 1 second.

Medium Priority

Several-hundred-page local terminal file system capacity for backup and privacy.

Alternate computer support on local processors or other systems accessible through network.

Local processor input and editing.

Noninteractive facilities available if desired.

User Control and System Feedback

High Priority

CRT display screen capable of displaying straight text.

Many objects for each command action: words, text, sentences, special typeface, phrases, paragraphs, pages, headings, captions, footnotes, equations, lists, table entities.

Structural filters.

Full addressing scheme:

Cursor pointing.

General location description.

"Undo" facility.

Feedback available.

Help available in prose description.

Syntactic help available through the system.

Medium Priority

Filters by content.

Organizational units as objects: documents, volumes, chapters, groups of structural entities.

Repeatable commands.

User can stop any system process.

Commands may be tailored to user (or group) needs and styles.

Record of date and time of change and person making that change associated with material.

Low Priority

Windowing capability: dividing screen into several areas for display of material.

Teletypewriter system as supplement: as similar to the display system conceptually as possible.

Feedback may be controlled according to user desires.

Menu or function button interfaces also available.

Medium Priority--Specialized Applications

CRT display screen capable of displaying formatted as printed with font changes, headers, etc.

System will interrogate for parameters for processes.

Work Station Environment

High Priority

Full-page alphanumeric display.

Cursor controller.

Photographic or xerographic printer (produces different fonts but not necessarily drawings).

Good working environment:

Sufficient lighting.

Appropriate noise level.

Comfortable and healthy furniture.

Large adjustable work station table.

Medium Priority

24-line by 80-column alphanumeric display.

Local processing via floppy disc or cassette.

Scrolling.

Low Priority

Multiple windows and multiple display work stations.

Interface to mixed text and graphics printer.

Impact printer.

High Priority--Specialized Applications

Formatting display, larger than 140 lines by 170 columns.

Drawing table display for illustration and layout, approximately 3 by 4 feet.

Ability to display special characters, such as Greek alphabet and math symbols.

Drawing pen.

Interface to phototypesetter.

Medium Priority--Specialized Applications

CRT displays with color.

File System

High Priority

Hierarchical structure.

No multiple write access except for terminal sharing.

Archive service.

Sequential numbering.

Medium Priority

Indexing system.

Hierarchical numbering.

High Priority--Specialized Applications

User-controlled access to files.

Storage of nontextual data.

Medium Priority--Specialized Applications

Limitless documents.